INSTRUCTION MANUAL

TYPE

RM31A

MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

INSTRUCTION MANUAL

Serial Number 26920

TYPE RM31A

Tektronix, Inc.

S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon ● Phone MI 4-0161 ● Cables: Tektronix

Tektronix International A.G.

Terrassenweg 1A ● Zug, Switzerland ● PH. 042-49192 ● Cable: Tekintag, Zug Switzerland ● Telex 53.574

070-301

SPECIAL TYPE RM31A INFORMATION

General Information

The oscilloscope for which this manual was prepared is a standard Type 531A specially modified for rack mounting. Electrically, the instrument is in every way identical with the standard Type 531A. All information in the man- concerning circuit descriptions, operation, maintenance and recalibration apply equally to the Type RM 31A. Front panel controls are located in exactly the same place with respect to each other. The silk-screened control descriptions on the front panel have merely been rotated 90° left so that the instrument may be operated in the rack-mount position with the longest dimension in a horizontal plane. Parts lists and circuit diagrams are also equally applicable to either the "upright" or rack-mounted instruments.

Rack-Mounting Procedure

The Type RM 31A comes to you ready for quick and easy permanent mounting in a standard relay rack. Installation of only four mounting screws will give a solid installation with easy accessibility to all parts of the instrument. In selecting a location for mounting, it is well to allow for 3½ to 4 feet of clearance to the front of the rack to permit extending of the instrument fully out of the cabinet for maintenance or operational purposes. This will permit tilting the oscilloscope up or down in the Chassis-Traks, and still allow working room in front. The Type RM31A cabinet extends 21 and three-quarter inches from the face of the rack to the back of the air filter when the instrument is fully engaged within the cabinet and locked in place. It is also necessary to allow additional clearance to the rear for purposes of air circulation. The Type RM31A is cooled by a fan at the rear of the instrument, and sufficient air circulation is an absolute necessity for protection of operating components within the oscilloscope.

To mount the Type RM31A cabinet in a rack, first remove the oscilloscope from the cabinet. This is done by first releasing the four locking screws at the corners of the front panel, then merely sliding the instrument out as far as it will go and pressing the slide release buttons to disengage the Chassis-Trak brackets on either side.

Next, select the height on the rack where you want the top of the cabinet to come. Then measure down one and seven-sixteenths inches on each side of the rack. This will be the location for the center of the top mounting screw. Center-to-center measurement from this point down to the lower mounting screw holes is exactly 11 inches. After holes for mounting screws are properly located, hold the cabinet in place behind the rack and mount the screws. If your relay rack does not provide for support of the Type RM31A cabinet at the rear, it may be advisable to use more than four mounting screws for additional support and rigidity.

After the cabinet is mounted and firmly anchored into the relay rack, it is merely necessary to re-mount the instrument within the Chassis-Traks and slide it back into the cabinet. When the locking screws on the front panel are tightened, your oscilloscope should be ready for operation as soon as power is supplied.

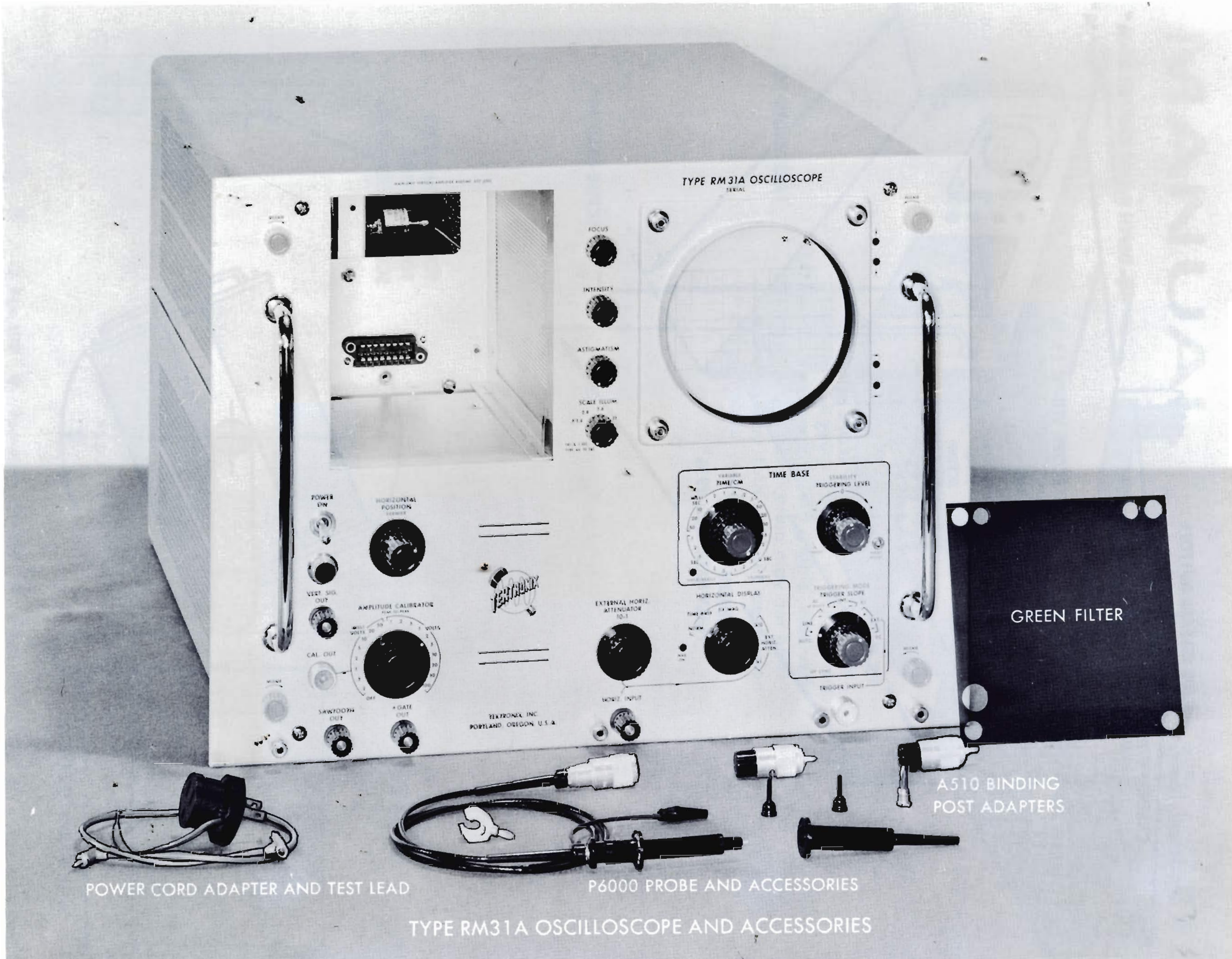
The Chassis-Traks are properly mounted with the Type RM31A cabinet at the factory. It should not be necessary for you to change their adjustments within the cabinet..

Operation

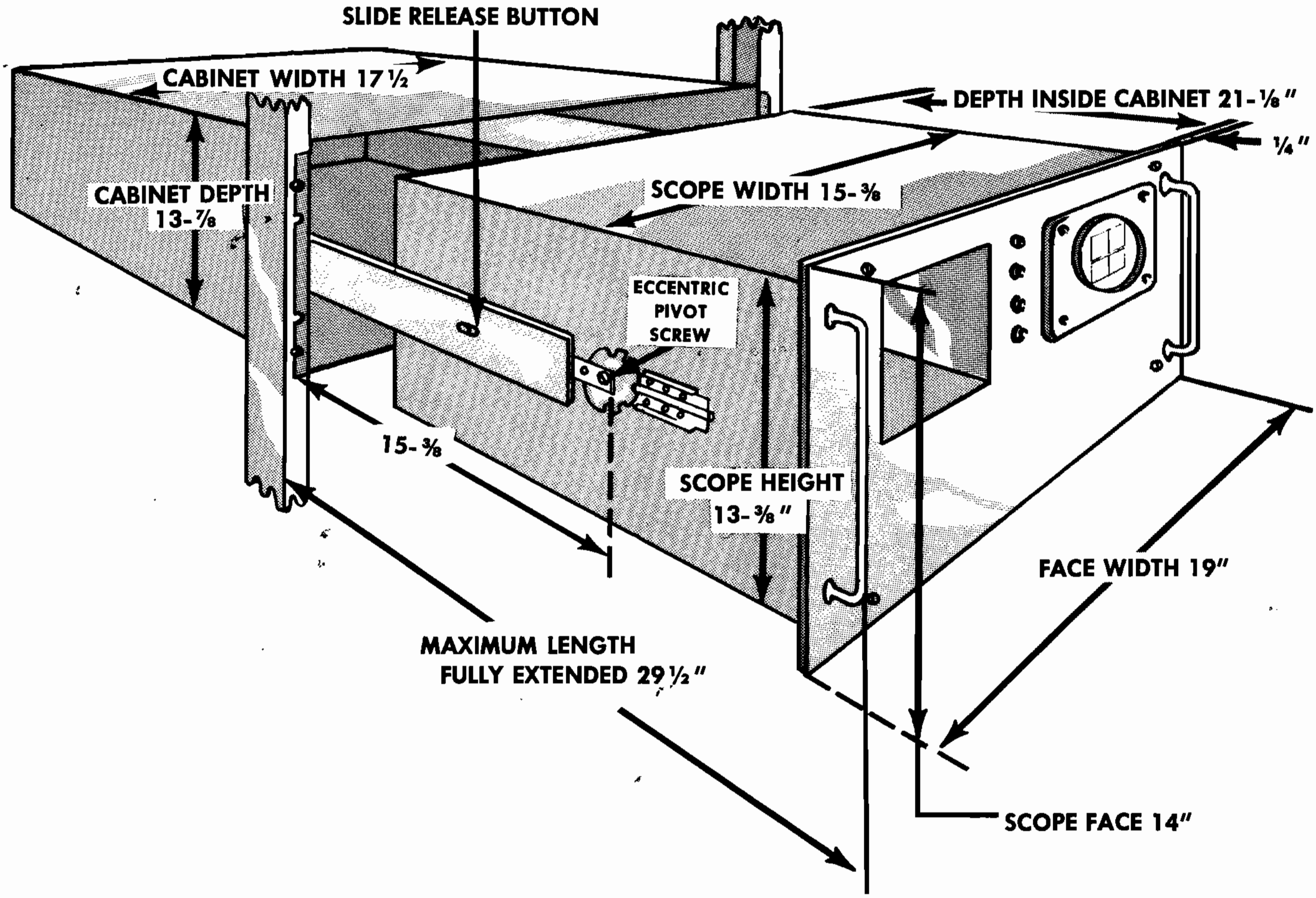
It may sometimes be desirable or necessary to operate your Type RM31A in an extended position outside the cabinet. To do so, it will be necessary to plug in a 3-wire power cord between the cabinet power outlet and the instrument proper. Be sure that this cord is long enough to allow for extending the instrument all the way out of the cabinet, and for any tilting upward or downward. The added power cord can easily be installed from the rear when the instrument is extended.

Modification Information

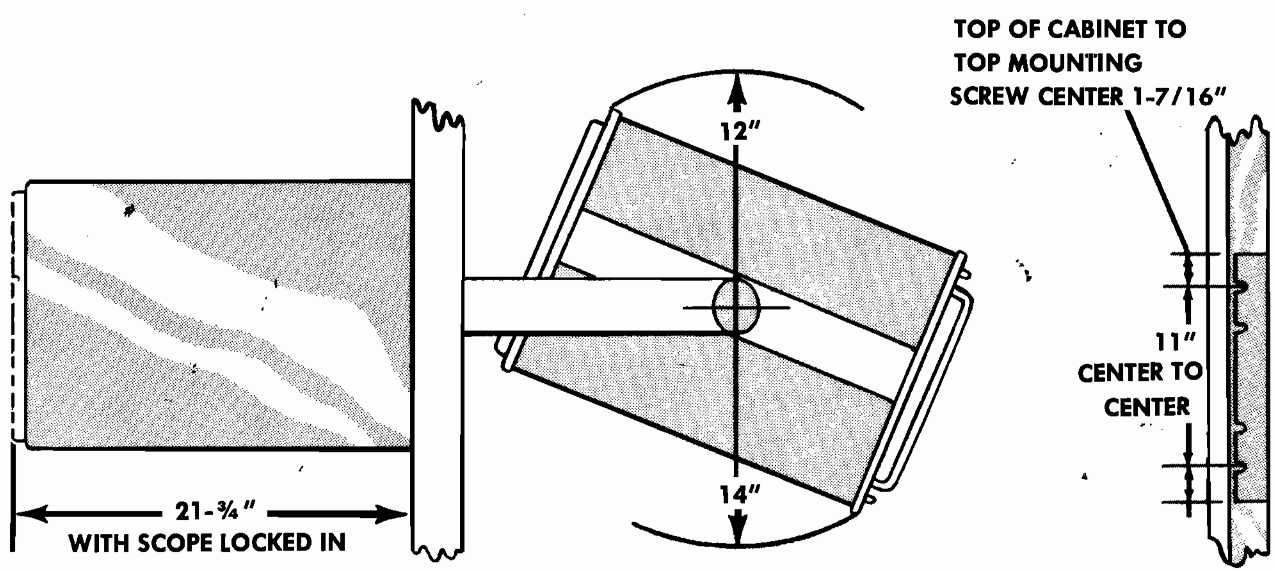
From time to time, Tektronix oscilloscopes are modified by changing or adding circuit components for the purpose of improving their performance and reliability. Your instruction manual indicates these changes in the Parts Lists and Circuit Diagrams where applicable, showing the Serial Numbers at which changes have occured. While the same improvements are added to your rack-mounting instruments as to standard scopes, they generally occur at different Serial Numbers.



TYPE RM31A OSCILLOSCOPE AND ACCESSORIES



SLIDE RELEASE BUTTON
CABINET WIDTH 17½
DEPTH INSIDE CABINET 21-⅛″
¼″
CABINET DEPTH 13-⅞
SCOPE WIDTH 15-⅜
ECCENTRIC PIVOT SCREW
15-⅜
SCOPE HEIGHT 13-⅜″
FACE WIDTH 19″
MAXIMUM LENGTH FULLY EXTENDED 29½″
SCOPE FACE 14″



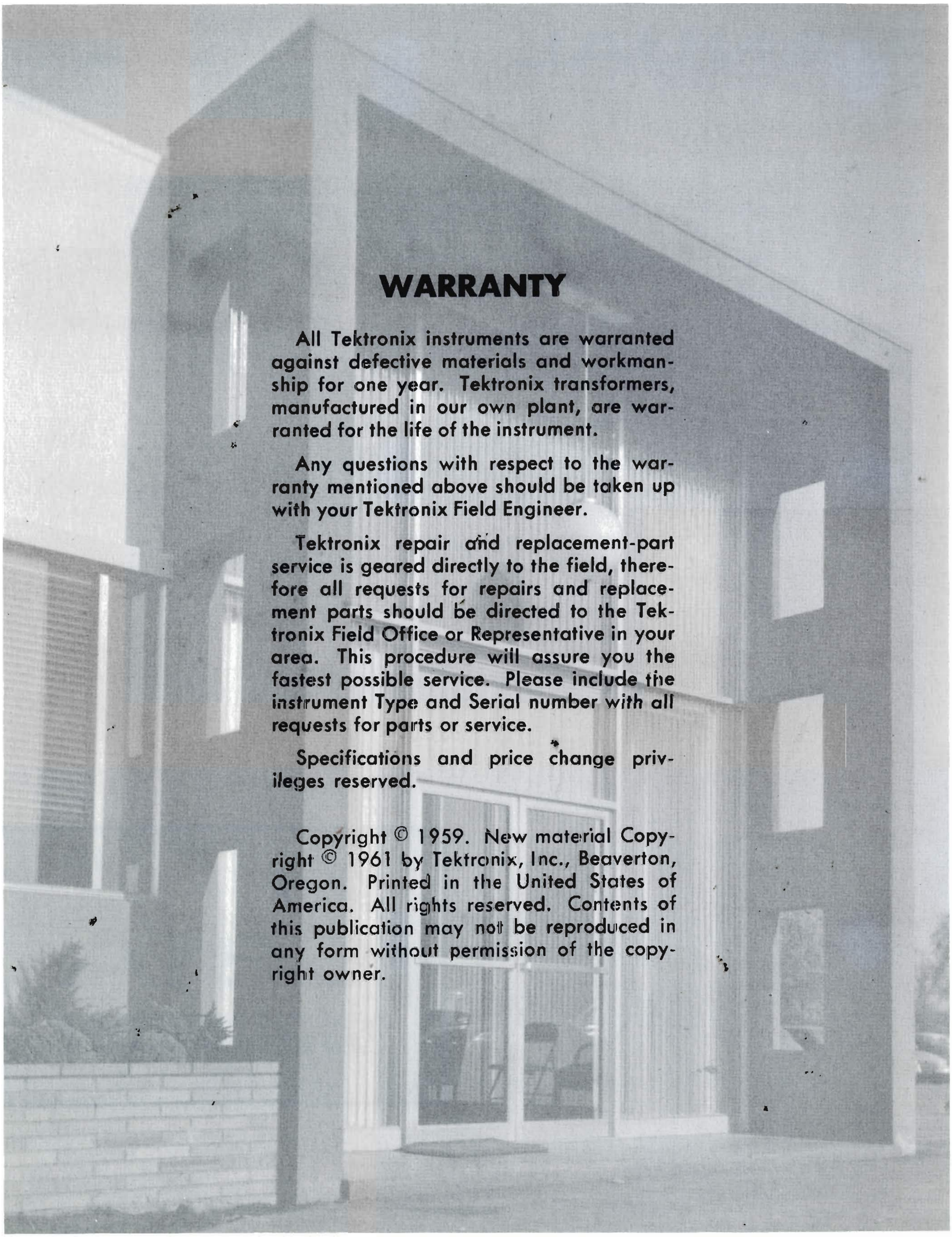
TOP OF CABINET TO TOP MOUNTING SCREW CENTER 1-7/16″
12″
14″
11″ CENTER TO CENTER
21-¾″ WITH SCOPE LOCKED IN

INSTRUCTION MANUAL

Serial Number ____________

TYPE 531A OSCILLOSCOPE

Tektronix, Inc.
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon ● Phone MI 4-0161 ● Cables: Tektronix
070-130—531A



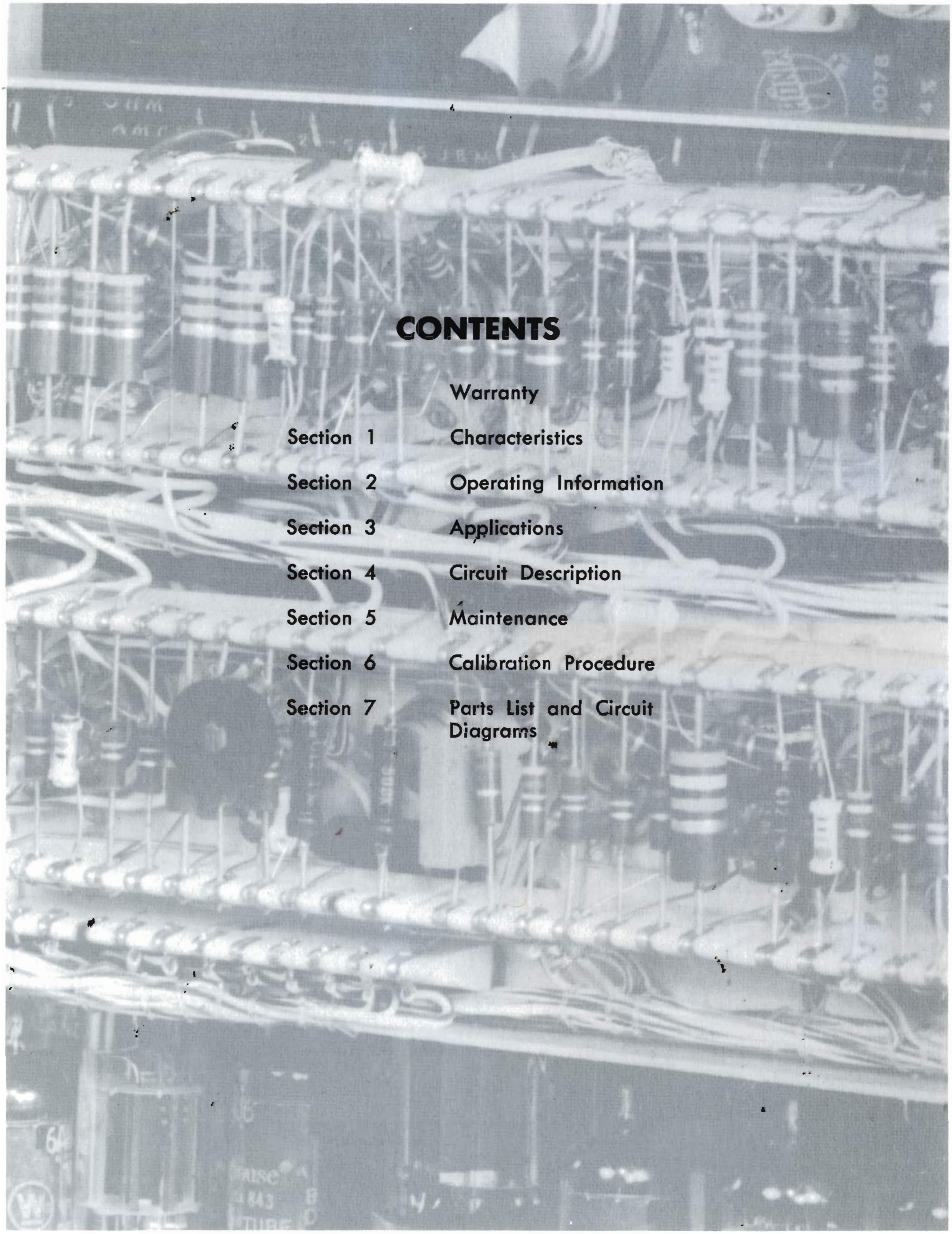
WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

Specifications and price change privileges reserved.



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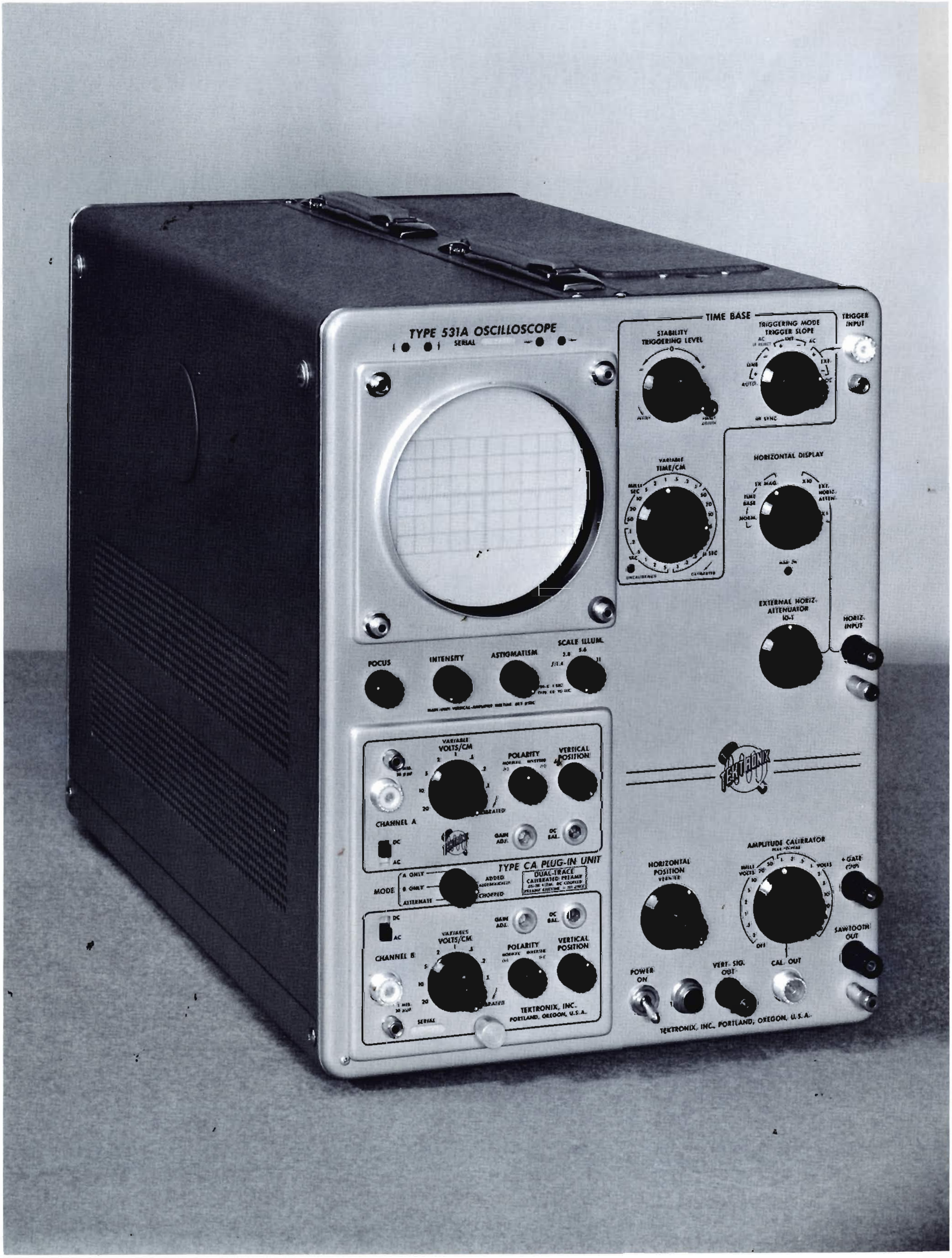
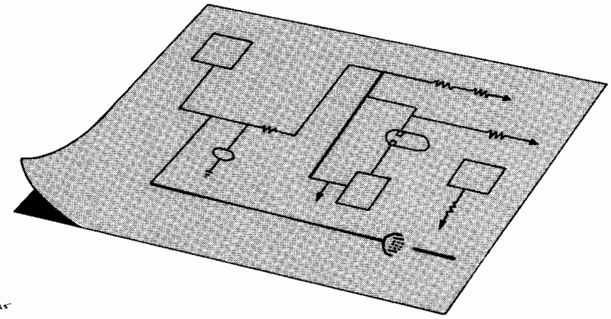

TYPE 531A OSCILLOSCOPE
TIME BASE
STABILITY
TRIGGERING LEVEL
TRIGGERING MODE
TRIGGER SLOPE
TRIGGER INPUT
VARIABLE
TIME/CM
HORIZONTAL DISPLAY
EXTERNAL HORIZ. ATTENUATOR
HORIZ. INPUT
FOCUS
INTENSITY
ASTIGMATISM
SCALE ILLUM.
VARIABLE
VOLTS/CM
POLARITY
VERTICAL POSITION
CHANNEL A
TYPE CA PLUG-IN UNIT
DUAL-TRACE
MODE
A ONLY
B ONLY
ALTERNATE
ADDED
CHOPPED
CHANNEL B
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.
TEKTRONIX
HORIZONTAL POSITION
AMPLITUDE CALIBRATOR
POWER ON
VERT. SIG. OUT
CAL. OUT
SAWTOOTH OUT
TEKTRONIX, INC. PORTLAND, OREGON, U.S.A.

Type 531A



SECTION 1
CHARACTERISTICS

General

The Tektronix Type 531A Oscilloscope is a general purpose instrument well suited to laboratory use. Plug-in preamplifiers are used in the vertical-deflection system, permitting the instrument to be used in many specialized application, including, among others, wide-band, dual-trace, low-level, differential, maximum frequency response and risetime, and transistor risetime checking.

Vertical Deflection System

All specifications for the Vertical Deflection System of the Type 531A Oscilloscope depend upon the plug-in unit used with the instrument. The following specifications are given assuming that a type K Plug-In Unit is used.

Bandpass—DC to 15 mc (down no more than 3 db at 15 mc).

Risetime—approximately 0.023 microsecond.

Delay Line—Balanced network Signal Delay—0.2 μsec.

Horizontal Deflection System

Triggering Modes—Automatic, AC Low Frequency Reject, AC, DC and High Frequency Sync.

Triggering Signal Requirements

Internal—a signal producing 2 mm of vertical deflection.

External—a signal of 0.2 volt to 10 volts, peak-to-peak. (The sweep will trigger on larger signals, but the TRIGGERING LEVEL control operates over a ±10 volt range.)

Triggering Frequency Range—triggered operation to 5 mc.

Synchronizing Signal Requirements

Internal—a signal producing 2 cm of vertical deflection.

External—a signal of 2 volts.

Synchronizing Frequency Range—synchronized operation 5 mc to 30 mc.

Sweep Rates

0.1 microsecond to 5 seconds per centimeter in 24 accurately calibrated steps. An uncalibrated control permits sweep rates to be varied continuously between 0.1 microsecond and approximately 12 seconds per centimeter. Calibrated sweep rates are typically within 1%, and in all cases within 3%, of the indicated sweep rate.

Magnifier

Provides a 5-times magnification of the center 2-centimeter portion of the oscilloscope display.

Extends the fastest sweep rate to 0.02 microsecond per centimeter.

Unblanking

DC coupling

External Horizontal Signal Input

Deflection Factor—0.2 v/cm or less to 15 v/cm or greater, continuously variable.

Frequency response—from dc to 240 kc. Response down 3 db at 240 kc.

Input impedance—approximately 47 pf, paralled by 1 megohm.

OTHER CHARACTERISTICS

Cathode-Ray Tube

Type T533/P2—P1, P7 and P11 phosphors optional.

Accelerating potential—10,000 volts.

Vertical Deflection Factor—approx. 10 v/cm.

Horizontal Deflection Factor—approx. 28 v/cm.

Amplitude Calibrator

Square-wave output at approximately 1 kc.

Output Voltages—0.2 millivolt to 100 volts peak-to-peak in 18 calibrated steps.

Accuracy—peak-to-peak amplitude of square waves within 3% of indicated voltage.

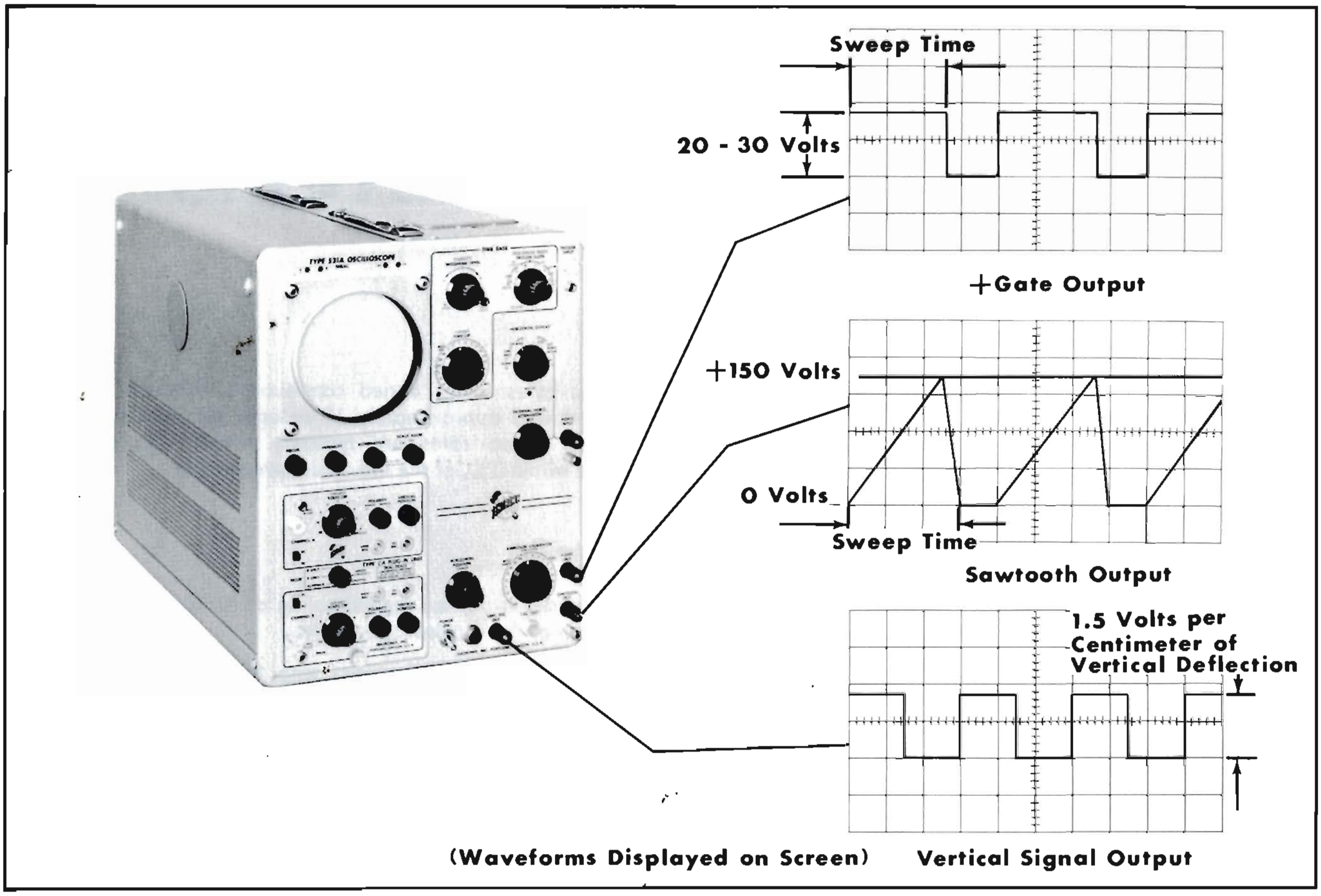


Fig. 1-1. Output waveforms available at the oscilloscope front panel.

Power Supplies

Electronically regulated for stable operation with widely varying line voltages and loads.

Line voltage requirements—105 v to 125 v, or 210 v to 250 v 50 to 60 cycles.

Power—500 watts with Type CA Plug-In Unit.

Output Waveforms Available

+Gate Output—approximately 20 volts peak-to-peak with same duration as sweep.

Sawtooth Output—Sweep sawtooth waveform, approximately 150 volts maximum.

Vertical Signal Output—output from vertical deflection system, approximately 1.5 volts peak-to-peak per centimeter of vertical deflection.

Mechanical Specifications

Ventilation—filtered, forced air. Thermal relay interrupts instrument power in the event of overheating.

Finish—photoetched, anodized panels. Blue finish, perforated cabinets.

Construction—aluminum alloy chassis and three-piece cabinet.

Dimensions—24" long, 13" wide, 16¾" high.

Weight—61½ pounds.

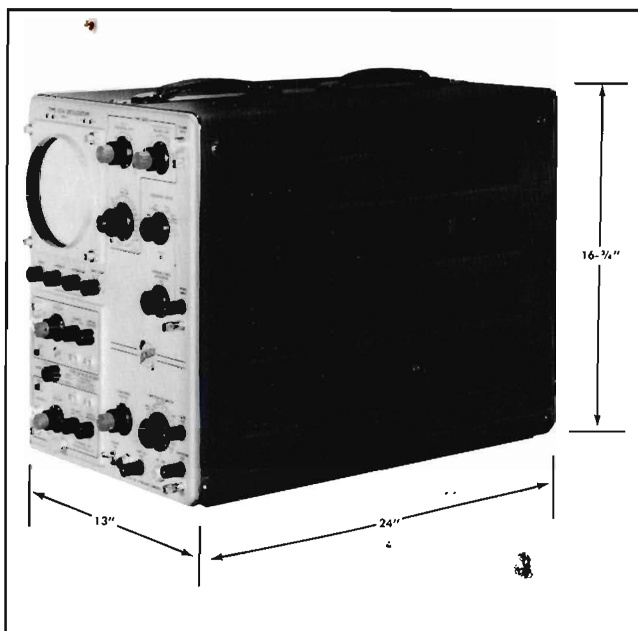


Fig. 1-2. Type 531A Oscilloscope Dimensions.

PLUG-IN PREAMPLIFIER CHARACTERISTICS FOR TYPE 531A OSCILLOSCOPES

PLUG-IN TYPE	CALIBRATED DEFLECTION FACTOR	PASSBAND	RISETIME	INPUT CAPACITANCE
TYPE A Wide-Band DC Coupled	0.05 v/cm to 20 v/cm	dc to 14 mc	25 nsec	47 pf
TYPE B Wide-Band High-Gain DC Coupled	5 mv/cm to 0.05 v/cm 0.05 v/cm to 20 v/cm	2 c to 10 mc dc to 14 mc	35 nsec 25 nsec	47 pf
TYPE CA Dual-Trace DC Coupled	0.05 v/cm to 20 v/cm	dc to 15 mc	23 nsec	20 pf
TYPE D High-Gain DC Coupled Differential	1 mv/cm to 50 v/cm†	dc to 2 mc	0.18 μsec	47 pf
TYPE E Low-Level AC Coupled Differential	50 μv/cm to 10 mv/cm	0.06 cycles to 60 kc	6 μsec	50 pf
TYPE G DC Wide-Band Coupled Differential	0.05 v/cm to 20 v/cm	dc to 14 mc	25 nsec	47 pf
TYPE H DC Coupled High-Gain Wide-Band	5 mv/cm to 20 v/cm	dc to 11 mc	31 nsec	47 pf
TYPE K Fast-Rise DC Coupled	0.05 v/cm to 20 v/cm	dc to 15 mc	23 nsec	20 pf
TYPE L Fast-Rise High-Gain DC Coupled	5 mv/cm to 2 v/cm 0.05 v/cm to 20 v/cm	3 c to 15 mc dc to 15 mc	23 nsec 23 nsec	20 pf
TYPE N* Pulse Sampling	10 mv/cm	600 mc	0.6 nsec	Input Impedance 50 ohms
TYPE P* is a fast-rise step-function test signal unit.				
TYPE Q* Strain Gage	10 μstrain/div to 10,000 μstrain/div	dc to 6 kc	60 μsec	Adjustable
TYPE R* Transistor Risetime	0.5 ma/cm to 100 ma/cm		23 nsec	
TYPE S* Semiconductor Diode Recovery	0.05 v/cm and 0.5 v/cm			
TYPE T* Time-Base Generator				
TYPE Z* DC Coupled Differential Comparator	0.05 v/cm to 25 v/cm	dc to 10 mc	35 nsec	24 pf

* More data available on the special-purpose plug-in units in the following paragraphs.

† At sensitivities greater than 0.05 v/cm, maximum bandpass is less than 2 mc. At 1 mv/cm, it is approximately 350 kc.

Accessories

2—Type P6008 Probes, 010-127

2—Type A510 Binding Post Adapters, BNC, 103-033

1—Test Lead (012-031)

1—Green Graticule Filter, 378-514

1—3 to 2-wire Adapter, 103-013

1—3-conductor power cord, 161-010

2—Instruction Manuals.

Type N

The Type N Sampling Unit is designed for use with Tektronix plug-in type oscilloscopes. The sampling system thus formed permits the display of repetitive signals with fractional nanosecond (10^{-9} second or nsec) risetime. By taking successive samples at a slightly later time at each recurrence of the pulse under observation, the Type N reconstructs the pulse on a relatively long time-base. Specifications of the Type N include a risetime of 0.6 nsec, corresponding to a maximum bandpass of approximately 600 mc; a sensitivity of 10 mv/cm with 2 mv or less noise; and a dynamic range of ±120 mv minimum linear range before overloading results.

Accidental overload of ±4 volts dc is permissible.

Type P

The Type P Plug-In Unit generates a fast-rise step-function test signal of known waveform, simulating the output of an ideally compensated Type K Unit driven with a Tektronix Type 107 Square-Wave Generator. The Type P permits the standardization of the main-unit vertical amplifier transient response of a Tektronix convertible oscilloscope. Risetime of the Type P is approximately 4 nanoseconds when it is used to standardize a Type 530-Series Oscilloscope. Pulse repetition rate is 240 step functions per second, with either positive or negative polarity. Step function amplitude is continuously adjustable between 0 and 3 major graticule divisions.

Type Q

The Type Q Plug-In Unit permits any Tektronix convertible oscilloscope such as the Type 531A to be operated with strain gages and other transducers. Excitation voltages for the strain gages and transducers are provided by the plug-in unit. The unit provides high gain, low noise, and extremely low drift. Frequency response of the Type Q Plug-In Unit is DC to 6 kc; risetime is approximately 60 microseconds. Strain sensitivity is calibrated in 10 steps from 10 microstrain per major graticule division to 10,000 microstrain per division, and is continuously variable between steps.

Type R

The Type R Plug-In Unit is a combined power supply and pulse generator which is used to measure the high-frequency characteristics of junction transistors by the pulse-response method. When the Type R is used in an oscilloscope having a delay line; delay time, risetime, storage time, and falltime may be displayed simultaneously. A pushbutton switch connects a front-panel terminal directly to the input of the oscilloscope for observing externally derived waveforms.

Pulse risetime of the Type R Unit is less than 5 nanoseconds, so measurements depend on the risetime of the oscilloscope used. Pulse amplitudes are 8 fixed, calibrated steps from 0.05 to 10 volts, adjustable between steps. Pulse recurrence frequency is 120 pulses per second.

Type S

The Type S Plug-In Unit is designed for use with Tektronix Wide-Band convertible oscilloscopes. The slower risetime of the Tektronix 530-Series Oscilloscopes will affect the ability of the S Unit to analyze fast semiconductor diodes. Using the Type S, voltage across a test diode is displayed as a function of time.

Certain diode parameters, such as junction resistance, junction capacitance, and the stored charge at the junction, can be measured readily and reliably from the display. Performance of a diode in a particular circuit can be predicted by analyzing the recovery and "turn-on" characteristics. Since it is essentiallly a means for plotting voltage across an element while passing constant current through it, the unit can be used for other applications as well. For example: observing the junction characteristics of transistors, or measuring the resistance, capacitance or inductance of circuit components.

The Type S offers calibrated forward currents in five fixed steps from 1 to 20 milliamps, and reverse currents calibrated in six steps from 0 to 2 milliamps. Diode shunt capacitance is 9 picofarads, and deflection factors are 0.05 v/cm and 0.5 v/cm, calibrated.

Type T

The Type T Time-Base Generator provides sawtooth sweep voltages from 0.2 μsec/div. The trigger source may be line frequency, external ac or dc coupled, automatic or high-frequency sync. The triggering point can be on either rising or falling slope of the waveform, and triggering level is adjustable. A signal of 0.2 to 50 volts is required for triggering.

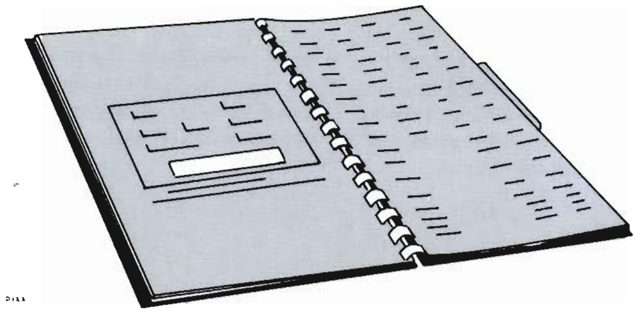
Type Z

The Type Z Plug-In extends the accuracy of oscilloscope voltage measurements. It can be used in three modes of operation: (1) as conventional preamplifier, (2) as a differential input preamplifier, or (3) as a calibrated differential comparator. With sensitivity of 50 mv/cm and insertion voltage range of ±100 volts, the effective scale range is ±2000 cm. Maximum resolution of the Type Z Unit is 0.005%.

As a conventional preamplifier, the Type Z Unit offers a passband of dc to 10 mc for the 531A for signals that do not overscan the screen. The deflection factors are 0.05 volts/cm to 25 v/cm in 9 fixed, calibrated steps.

As a differential input preamplifier, the Type Z accepts a common-mode signal level ±100 volts with input attenuation X1, and offers a common-mode rejection ratio of 40,000 to 1. Maximum input signal is 1 volt/7 nsec, or —1 volt/5 nsec.

As a calibrated differential comparator, the Type Z makes available three comparison voltage ranges; from zero to ±1 volt, zero to ±10 volts, and zero to ±100 volts.



SECTION 2

OPERATING INSTRUCTIONS

General

The Type 531A Oscilloscope is an extremely versatile instrument which is adaptable to a great number of applications. However, to make full use of the instrument, it's important that you understand the operation and function of the various controls. This section of the Manual is designated to give you this information.

PRELIMINARY INSTRUCTIONS

Cooling

A fan maintains safe operating temperature in the Type 531A by circulating filtered air over the rectifiers and other components. When in operation, the instrument must be placed so that the air intake at the back is clear of any obstruction that might impede the flow of air. Side panels should also be in place for proper air circulation. The air filter should be kept clean, in accordance with cleaning instructions found in the Maintenance Section of the manual.

Under no circumstances should your Type 531A Oscilloscope be operated without the fan running. Without the fan, inside temperature of the oscilloscope will rise to a dangerous level in five to ten minutes. In this event, the thermal cutout switch will disconnect the power and keep it disconnected until the temperature drops to a safe level.

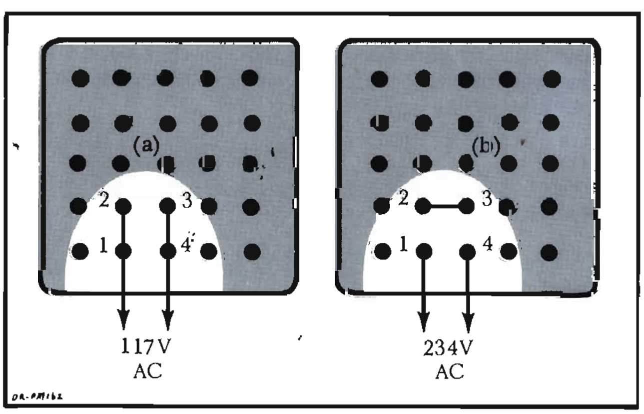


Fig. 2-1. Converting the power transformers from 105-125-volt operation to 210-250-volt operation.

Power Requirements

Unless tagged otherwise, this instrument is connected at the factory for operation at 105 to 125 volts, 50 to 60 cycles ac (117 volts nominal.) However, provisions are made for easy conversion to operation at 210 to 250 volts, 50 to 60 cycles (234 volts nominal).

The power transformer (T601) is provided with split input windings, normally connected in parallel for 117-volt operation, but which can be connected in series for 234-volt operation. Each of these split windings terminates in a nest of four terminal lugs (arranged in a square) on the underside of the transformer. The lugs are numbered 1, 2, 3 and 4 in a clockwise rotation.

Terminals 1 and 3 are connected to one winding and terminals 2 and 4 are connected to the second winding. The ac input leads are connected to terminals 1 and 4 for both 117-volt and 234-volt operation, so these connections do not have to be changed when converting from one line voltage to the other.

When wired for 117-volt operation, terminals 1 and 2 are joined by a bare bus wire, and terminals 3 and 4 are similarly joined, as shown in Fig. 2-1a. To convert these terminals, substitute a single connecting wire between terminals 2 and 3, as shown in Fig. 2-1b.

Fan Connections

The cooling fan is powered by a 117-volt ac motor. If the instrument is converted to operate from a 234-volt line, a change in the fan wiring must be made so that it operates from a 117-volt source.

To make the change from 117-volt to 234-volt operation, refer to the ceramic strip adjacent to one corner of the power transformer, as shown in Fig. 2-2. Unsolder the fan lead in the fifth slot at the ceramic strip, lift it free, and move it to the third slot as illustrated by the dotted line in Fig. 2-2. Use silver-bearing solder to solder the lead into the slot. The other fan lead connected at the second slot is not changed during the conversion from one line voltage to the other.

Fuse Data

Fuse data is silk-screened on the rear panel of the instrument adjacent to the fuse holder. Use only the recommended fuses for maximum over-current protection.

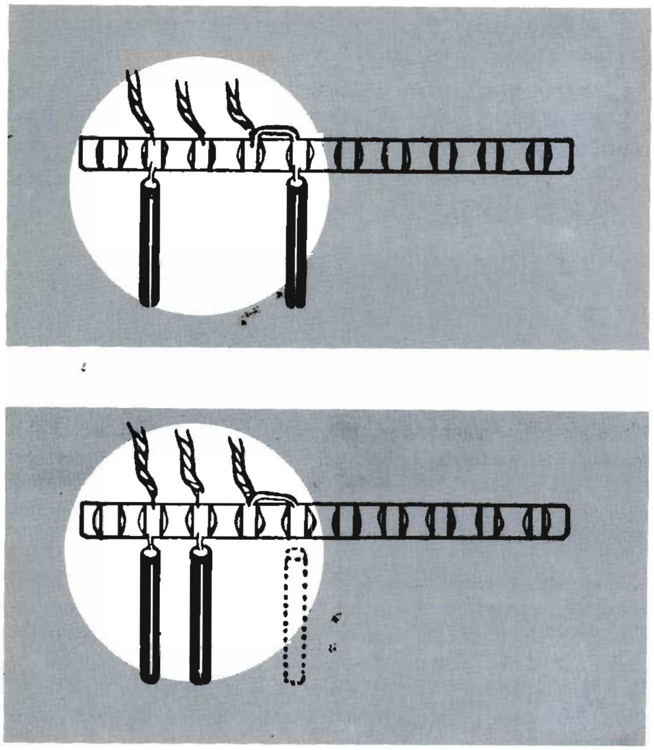


Fig. 2-2. Converting the Type 531A fan motor from 105-125-volt to 210-250-volt operation.

OSCILLOSCOPE OPERATION INFORMATION

Plug-In Units

The Type 531A Oscilloscope is designed to operate with any one of the Tektronix letter-series plug-in units. The particular plug-in unit used must be selected by you to satisfy the requirements of your application. In selecting the plug-in unit for any particular application, you must consider the bandpass, sensitivity, and type of input required for that application. Complete information on all available plug-in units will be found in the Characteristics Section of this manual.

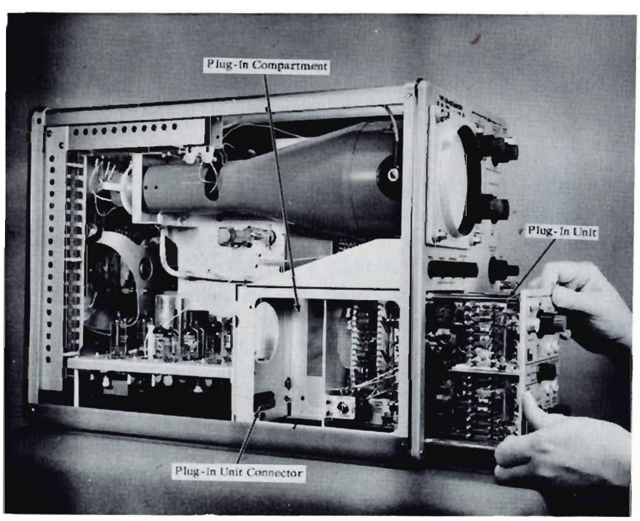


Fig. 2-3. Inserting the selected plug-in unit into the oscilloscope plug-in compartment.

Preparation for use

When the plug-in unit has been selected, insert it into the plug-in compartment of the oscilloscope and press firmly to insure that the connectors make proper contact (see Fig. 2-3). Tighten the plug-in unit locking control to hold the unit securely in place and turn the oscilloscope INTENSITY control fully counterclockwise. Connect the power cord to the rear of the instrument and to the power line and place the POWER switch in the ON position.

Time Delay

Time Delay relays used in the Type 531A Oscilloscopes delay operation of the instrument for approximately 25 seconds after the POWER switch is turned on to allow a brief tube warmup period. The delay allows the tube sufficient time to heat before the dc operating voltages are applied.

If the ac power is off for only an instant, the normal 25-second delay will occur before the instrument returns to full operation. This delay will occur regardless of whether the ac power is off because of a momentary power failure or is turned off with the POWER switch.

Focus and Astigmatism

The FOCUS and ASTIGMATISM controls operate in conjunction with each other to allow you to obtain a sharp, clearly defined spot or trace. The proper setting of the ASTIGMATISM control is obtained by rotating the FOCUS control fully clockwise, setting the HORIZONTAL DISPLAY switch at EXT. X10 and adjusting the INTENSITY control to obtain a spot on the screen. After positioning the spot to the center of the screen, the ASTIGMATISM control is adjusted for the most nearly circular spot possible. The FOCUS control is then adjusted to reduce the spot diameter as much as possible. You must be certain that all input signals to the oscilloscope are disconnected when you adjust the FOCUS and ASTIGMATISM controls.

Intensity Control

The INTENSITY control is used to adjust the brightness of the oscilloscope display. This permits you to compensate for changes in brightness resulting from changes in the sweep triggering rate. The INTENSITY control is rotated clockwise to increase brightness and counterclockwise to decrease it. Be careful when you use the INTENSITY control that the brightness is not turned up to where it will permanently damage the face of the cathode-ray tube. If brightness is turned up to the point where a halo forms around the spot, it should be turned down immediately.

Graticule Illumination Control

The graticule used with the Type 531A Oscilloscope is accurately marked with 10 horizontal and 6 vertical 1-centimeter divisions with 2-millimeter markings on the centerlines. These graticule markings allow you to make time and voltage measurements from the oscilloscope screen.

The graticule is illuminated by two lamps located at the top edge of the graticule. The graticule markings can be made either white or red by positioning the graticule so that either the clear bulb slots or those with red plastic inserts are next to the bulbs. Generally, the white graticule markings are better than the red for photographic purposes.

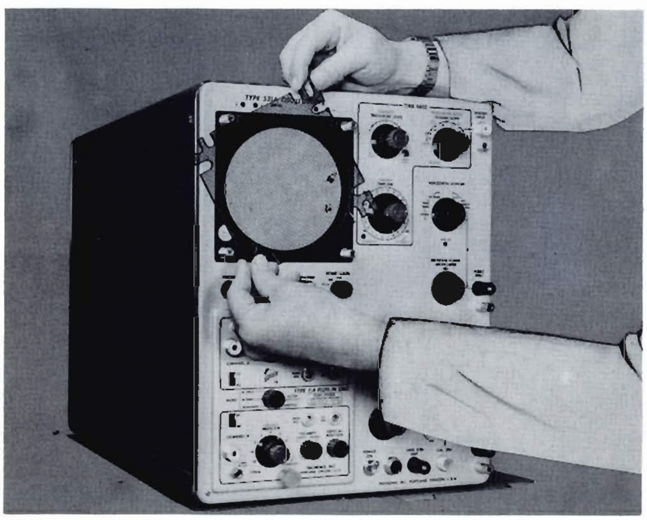


Fig. 2-4. Rotating the graticule to change the color of the graticule markings.

Graticule illumination is adjusted by the SCALE ILLUM. control located just under the oscilloscope screen. Rotating the control clockwise increases the brightness of the graticule markings, and turning it counterclockwise decreases brightness. For convenience in photographing oscilloscope displays, the SCALE ILLUM. control is marked in approximate f-stops. These f-stops can be used with a shutter speed of 1 second when TRI-X film is used, or with a shutter speed of 10 seconds when Polaroid film is used. Regardless of the type of film used, better results can generally be obtained with white graticule markings. For best results, try to match the intensity of the trace with the brightness of the graticule markings.

Positioning Controls

Three controls are used with the Type 531A for positioning the trace on the oscilloscope screen. Two controls are used to set horizontal positioning of the trace. These are located on the front panel of the instrument. The third conrol is used to set vertical positioning, and is located on the front panel of the plug-in unit used with the oscilloscope. The Type 53/54C and Type CA Dual-Trace Plug-In Units have two Vertical Positioning Controls.

The two HORIZONTAL POSITION controls cause the trace to move to the right when they are rotated in the clockwise direction and to the left when rotated counterclockwise. Together, the two controls have a total positioning range of 12 to 60 centimeters, depending upon the degree of sweep magnification used. The black HORIZONTAL POSITION control has approximately three times the range of the red VERNIER control. The fine range of adjustment of the VERNIER control makes this control particularly useful whenever fine horizontal positioning is required, such as when various positions of sweep magnification are used.

The vertical positioning control has enough range to allow the trace to be positioned completely off the top or bottom of the screen or anywhere in between. The trace moves up when the control is turned clockwise and down when the control is turned counterclockwise.

Beam Position Indicators

Four small indicator lights located just above the oscilloscope screen indicate the position of the spot or trace. When one of these lamps is lit, it indicates that the trace is off-centered in the direction of the arrow. These four lights allow you to position the spot to the center of the screen even though the intensity is so low that the trace is not visible. When the sweep is running, the spot moves from the left side of the screen to the right and may cause both horizontal lamps to light each time the sweep runs.

Input Signal Connections

The electrical waveform to be observed is applied to one of the plug-in unit input connectors. The waveform is then connected through the vertical-deflection system of the plug-in unit and the oscilloscope to cause the spot to be deflected vertically and to trace out the waveform on the screen of the crt. The vertical size of the displayed waveform is adjusted with the plug-in unit VOLTS/CM switch. The VOLTS/CM switch is an accurately calibrated control which, when used with the graticule, allows you to make precise voltage measurements from the displayed waveforms. The operation of other plug-in unit controls varies between plug-in units. For information regarding the operation of these controls, refer to the instruction manual for the plug-in unit you are using.

Certain precautions must be taken when you are connecting the oscilloscope to the input signal source to insure that accurate information is obtained from the oscilloscope display. This is particularly true when you are observing low-level signals or waveforms containing high or extremely low-frequency components. For applications where you are observing low-level signals, unshielded input leads are unsatisfactory because they tend to pick up stray signals which produce erroneous oscilloscope displays. Shielded cables should be used whenever possible, with the shield connected to the chassis of both the oscilloscope and the signal source. Regardless of the type of input lead used, keep them as short as possible.

Distortion of the input waveforms may result if very low-frequency input signals are ac coupled into the oscilloscope, if high-frequency waveforms are not properly terminated, or

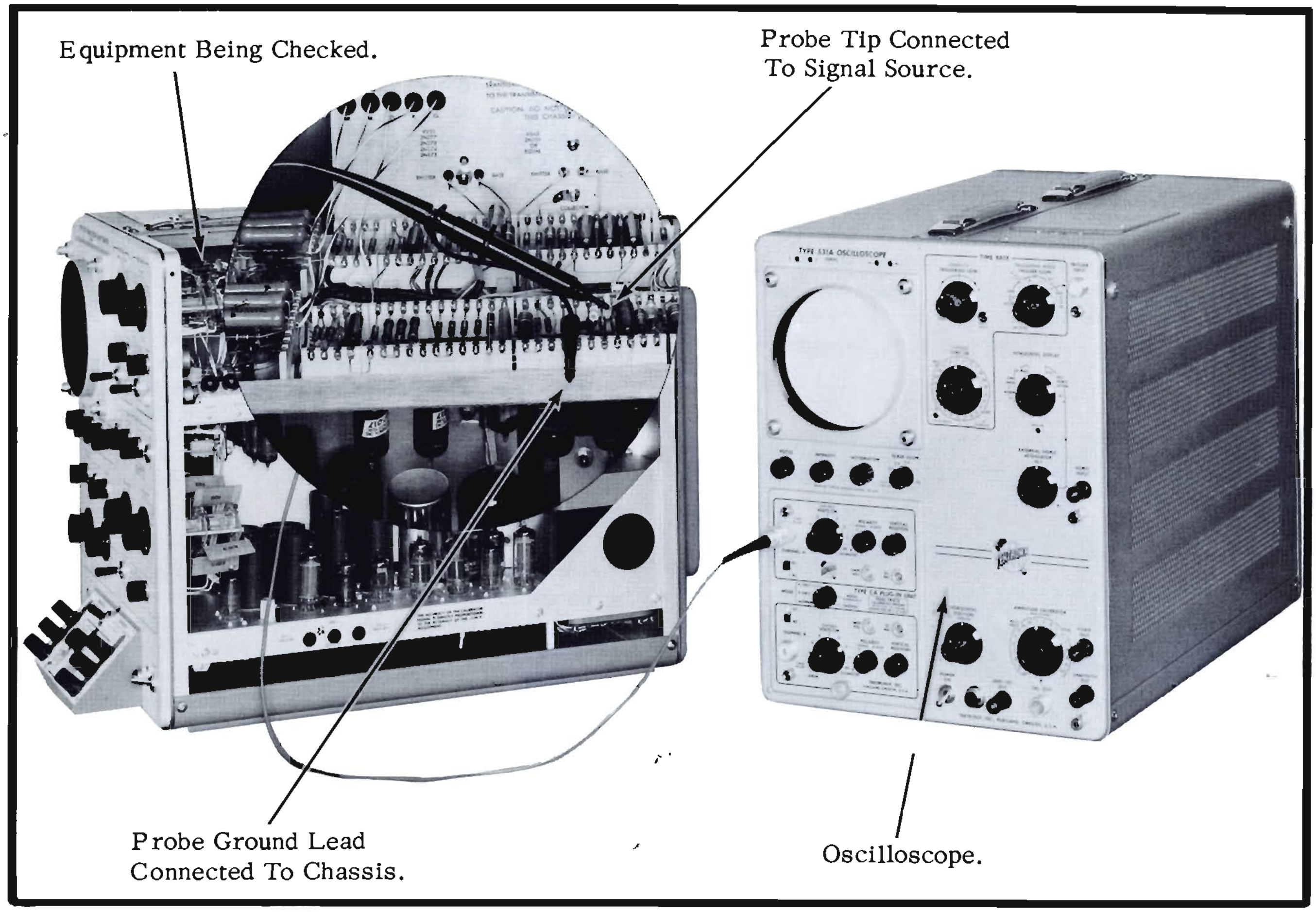


Fig. 2-5. Proper connection of a probe to the input signal source.

if the input waveform contains high-frequency components which exceed the passband of the oscilloscope and plug-in unit combinations You must be aware of the limitations of the instrument.

In analyzing the displayed waveform, you must consider the loading effect that the oscilloscope has on the input signal source. In most cases this loading effect is negligible, but in some applications, loading caused by the oscilloscope may materially alter the results obtained. In such cases you may want to use a probe to reduce the amount of loading.

Use of Probes

Occasionally, connecting the input of an oscilloscope to a signal source loads the source enough to adversely affect both the operation of the source and the waveform displayed on the oscilloscope. When this occurs, both capacitive and resistive loading due to the oscilloscope can be reduced to a negligible value by using an attenuator probe.

In addition to providing isolation of the oscilloscope from the signal source, an attenuator probe also decreases the amplitude of the displayed waveform by the attenuation factor of the probe. Use of a probe allows you to increase the vertical deflection factors of the oscilloscope to look at large amplitude signals which are beyond the normal limits of the oscilloscope and plug-in combination. Signal amplitudes, however, must be limited to the maximum allowable value of the probe used.

Before using a probe, you must check (and adjust if necessary) the compensation of the probe to prevent distortion of the applied waveform. To adjust the probe compensation, place the HORIZONTAL DISPLAY switch at NORM., the TIME BASE TRIGGERING MODE switch at AUTO, and the TIME BASE TRIGGER SLOPE switch at +INT. Turn up the intensity until the trace is visible and connect the probe tip to the CAL OUT connector. Set the AMPLITUDE CALIBRATOR switch for 2 centimeters of displayed signal. Set the TIME BASE TIME/CM switch to display approximately 3 or 4 cycles of the Calibrator waveform and adjust the probe compensation control to obtain flat tops on the displayed Calibrator square waves as shown in Fig. 2-6.

If a P6000 type probe is used, it is necessary to first unlock the Locking Sleeve by turning it counterclockwise. The probe is then compensated by rotating the probe body while watching the oscilloscope display for the desired waveform. When compensation is completed, carefully turn the Locking Sleeve clockwise to lock it without disturbing the adjustment of the probe.

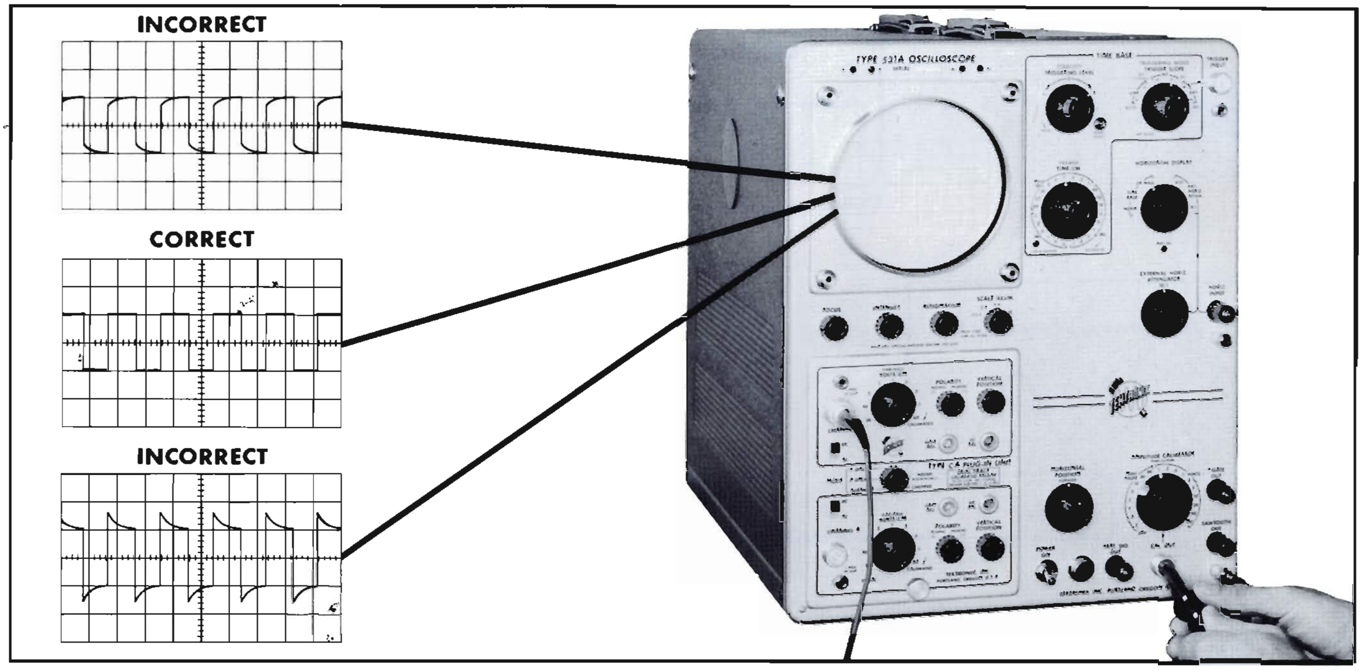


Fig. 2-6. When compensating the probe, it is adjusted to obtain an undistorted presentation of the calibrator square-wave.

HORIZONTAL DEFLECTION SYSTEM

Trigger Operation

For most uses of the oscilloscope a stable display of some waveforms is required. To accomplish this the oscilloscope can be operated so that the horizontal sweep starts at a given point on the displayed waveform. This is known as "triggered" operation. For the present, we will refer to the starting of the sweep, at the left side of the graticule, as "triggering" the sweep.

Triggered operation is useful for observing a waveform which may occur only once, or which may occur at random intervals. For any of these uses, the oscilloscope can be used in such a way that each horizontal sweep is triggered by some waveform other than the one being observed, but which bears a time relationship to the observed waveform.

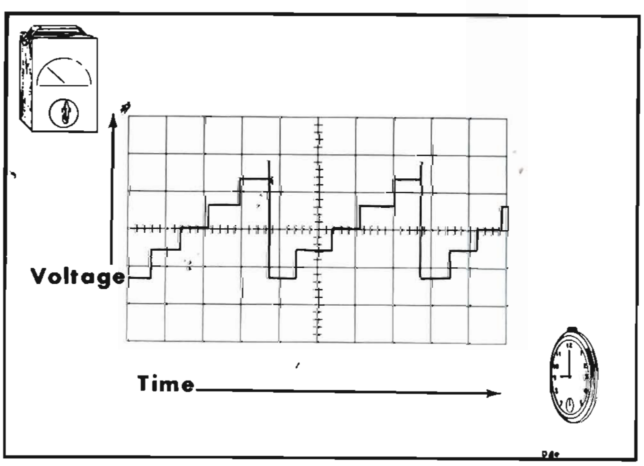


Fig. 2-7. The oscilloscope plots instantaneous voltage versus time thereby serving both as a voltmeter and a timer.

The waveform used to start the horizontal sweep is called the "triggering signal". whether it is the waveform being observed, or some other waveform. The instructions that follow tell you how to select this signal. They also contain information on triggering according to various modes, depending on the nature of the triggering signal.

Selecting the Triggering Signal

1. To trigger the sweep from the waveform being observed set the black TRIGGER SLOPE knob to INT. (+ or —).

2. To trigger the sweep from the powerline wave (as in the case when observing a waveform which has a time relationship to the power-line wave), set the black TRIGGER SLOPE knob to LINE (+ or —).

3. To trigger the sweep from some external waveform (one having a time relationship to the waveform being observed), connect the source of the triggering signal to the TRIGGER INPUT connector and set the black TRIGGER SLOPE knob to EXT (+ or —).

Refer to Fig. 2-8 for a complete pictorial presentation of the various triggering source options.

Selecting the Triggering Slope

The horizontal sweep can be triggered on either the rising (+ slope) or falling (— slope) portion of the triggering waveform as determined by the position of the TRIGGER

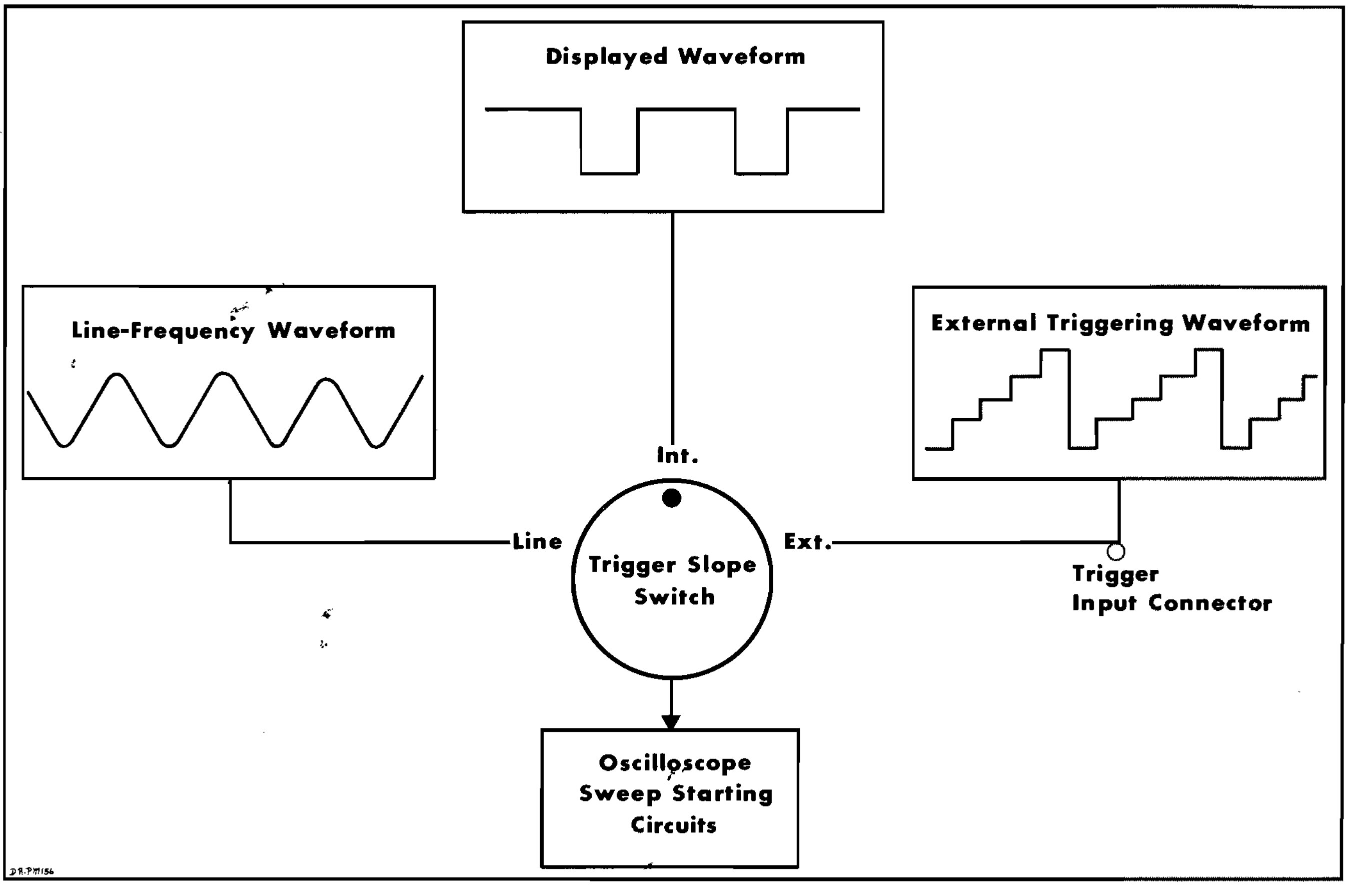


Fig. 2-8. The triggering signal is selected from three possible sources with the TRIGGER SLOPE control.

SLOPE switch. When the switch is in one of the + positions, the sweep is triggered on the rising portion of the triggering waveform; when the TRIGGER SLOPE switch is in one of the — positions, the sweep is triggered on the falling portion of the waveform. (see Fig. 2-9).

In many applications the triggering slope is not important, since triggering on either slope will provide a display which is suitable to the applicaton. However, in many other cases such as pulse measurements, the triggering slope is very important. If, while using a fast sweep, you wish to see the rise of a pulse, it will be necessary for you to trigger the sweep on the rising portion of the waveform by placing the TRIGGER SLOPE switch in one of the + positions. To observe the fall of a pulse at a fast sweep rate, it will be necessary to trigger the sweep on the fallinng portion of the waveform by placing the TRIGGER SLOPE switch in one of the —positions. In either case, selection of the wrong triggering slope will make it impossible for you to see the portion of the waveform you want to check.

Using the STABILITY and TRIGGER LEVEL Controls

Triggered operation in all modes except AUTOMATIC and HF SYNC may require proper settings of the STABILITY and TRIGGERING LEVEL controls. The TRIGGERING LEVEL control has no effect in either AUTOMATIC or HF SYNC modes.

The STABILITY control has a PRESET position at the fully counterclockwise setting of the control. This position permits proper triggering in many applications wthout necessitating additional adjustment of the STABILITY control. If it becomes difficult or impossible for you to obtain proper triggering with the STABILITY control at PRESET, you must then adjust the control. This is done with the TRIGGERING LEVEL control fully counterclockwise. The STABILITY control is rotated clockwise from the PRESET position until a trace appears on the screen. The proper Stability setting for a triggered display is then obtained by turning the knob slowly counterclockwise until the trace just disappears.

The TRIGGERING LEVEL control should then be turned slowly toward the 0 position until a stable display appears on the screen. The TRIGGERING LEVEL control also determines the exact point on the triggering waveform where triggering of the sweep occurs. Turning the control clockwise causes the sweep to trigger at more positive points on the waveform, while turning the control counterclockwise causes the sweep to trigger at more negative points. If the displayed waveform is vertically centered under the graticule, setting the TRIGGERING LEVEL control at 0 will cause the sweep to start at approximately the mid-voltage point of the waveform, except in DC mode.

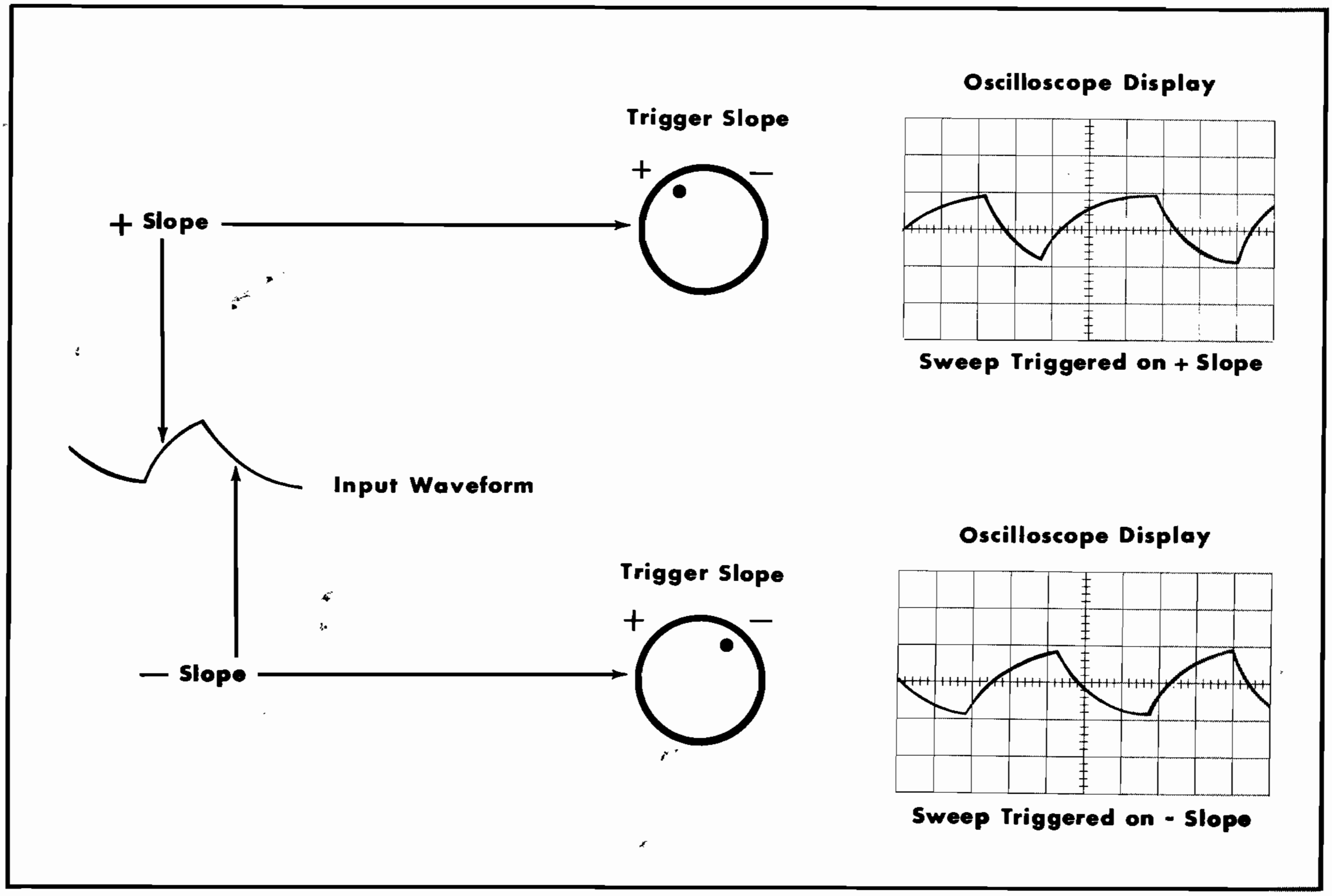


Fig. 2-9. Effects on the oscilloscope display produced by + and — settings of the TRIGGER SLOPE control.

Selecting the Triggering Mode

After selecting the triggering source and triggering slope, it is next necessary to select the triggring mode which will allow you to obtain the desired display. Five triggering modes are available. They are DC, AC, AC LOW FREQUENCY REJECT, AUTOMATIC and HIGH FREQUENCY SYNC.

Each of the triggering modes is designed to provide stable triggering from a certain type of waveform. For most applications however, several of the triggering modes will work equally well. For applications of this type, the triggering mode used is purely a matter of choice. The primary thing to consider in choosing the triggering mode is whether or not it allows you to obtain the display you want.

To determine the best mode of operation for a particular application, it is usually best to try each triggering mode in the application. The Automatic mode should be tried first since this triggering mode provides stable triggering in most applcations without the necessity of setting the STABILITY or TRIGGERING LEVEL controls. If the Automatic mode does not provide the desired display, it will then be necessary for you to try one or more of the other triggering modes.

AUTOMATIC Triggering Mode

The AUTOMATIC mode is most frequently used because of its ease of operation. This mode is useful in obtaining stable triggering from waveforms with frequencies of from approximately 60 cycles to 2 megacycles. The principal advantage of this type of operation is that it is not necessary to adjust either the STABILITY or TRIGGERING LEVEL controls to obtain a stable display. This permits you to observe a large number of waveforms with different shapes and amplitudes without adjusting any of the triggering controls. In the absence of a triggering signal, the sweep continues to run to provide a convenient reference trace on the oscilloscope screen.

The AUTOMATIC triggering mode is selected by placing the TRIGGERING MODE switch in the AUTO. position. The triggering source and slope is then selected and the input signal is applied to the oscilloscope. No other control adjustments are required. Since the TRIGGERING LEVEL control has no effect on the display when automatic triggering is used, it is impossible to select the point on the triggering waveform where the sweep is triggered. Each sweep is instead triggered at the average voltage point of the waveform.

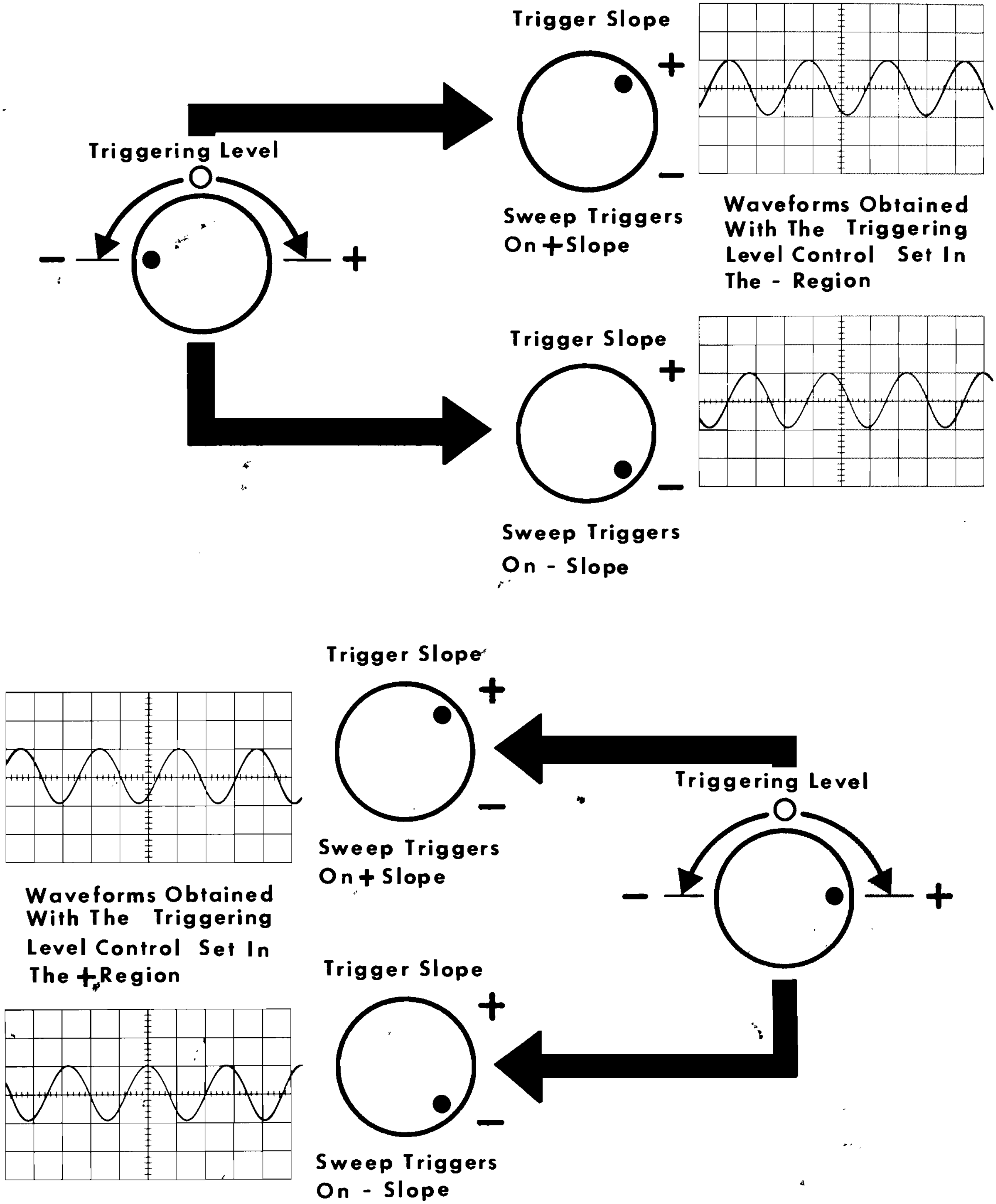


Fig. 2-10. Effects on the oscilloscope display produced by + and — settings of the TRIGGERING LEVEL control. When the TRIGGERING LEVEL control is set in the + region, the sweep is triggered on the upper portion of the input waveform; when it is set in the — region, the sweep is triggered on the lower portion of the input waveform. The TRIGGER SLOPE control determines whether the sweep is triggered on the rising portion or the falling portion of the input waveform.

DC Triggering Mode

In the DC mode, the sweep can be triggered from periodic signals in the range from dc to 5 mc. This mode is especially useful with trigger signals that change slowly, and is also useful when it is desired to trigger at a certain point (voltage level) on a waveform with respect to ground.

Another application of the DC triggering mode is to attain a stable display of a random-pulse train. The average voltage of this type of signal is dependent upon the time duration and amplitude of each pulse and the time lapse between successive pulses. Since these are variable quantities in a random-pulse train, the average voltage will also vary. This is likely to cause unstable triggering in the AC modes. In the DC mode, however, the circuits are sensitive to the instantaneous voltage only. Changes in the average voltage do not alter the operation of the circuits. As a result, the TRIGGERING LEVEL control can be adjusted to initiate a sweep whenever a pulse reaches the desired voltage.

AC Triggering Mode

Selection of the AC triggering mode is made by placing the TRIGGERING MODE switch in the AC position. This mode provides useful triggering in the frequency range of approximately 15 cycles to 5 mc. These frequency limits vary slightly depending upon the shapes and amplitude of the triggering waveform. In the AC mode, triggering is unaffected by the dc components of the triggering signal or by the vertical positioning of the trace. The triggering level can be selected to provide the desired display using the STABILITY and TRIGGERING LEVEL controls. These two controls are set as described for the DC mode.

AC LF REJECT Mode

The AC Low Frequency Reject triggering mode is used when the TRIGGERING MODE switch is in the AC LF Reject position. This mode is similar to the slower AC mode except that low-frequency waveforms are rejected by the triggering circuit. This triggering mode works well with high-frequency waveforms, but it may be difficult to obtain stable triggering with frequencies below approximately 1000 cycles.

Occasionally you may be required to obtain stable triggering from a fairly high-frequency waveform that is mixed with a great deal of low-frequency noise or line frequency pickup. In such cases the additional noise and pickup can make it very difficult to obtain a stable display. If this occurs, you can select the AC LF Reject triggering mode, thereby eliminating the effects of the low-frequency noise and pickup. The low frequencies are blocked from the triggering circuit while the high-frequency triggering waveform is passed to produce the stable triggering that you need. In all other respects, the two AC triggering modes are identical.

HF SYNC Triggering Mode

The High Frequency Synchronization Mode permits stable displays of waveform with frequencies higher than approximately 5 mc. Stability of the display is adjusted with the STABILITY control. The TRIGGERING LEVEL control is not used. To use the High Frequency Synchronization Mode, place the TRIGGERING MODE switch in the HF SYNC position. Turn the STABILITY control clockwise until a trace appears. Continue to adjust the STABILITY control until a stable display is obtained.

Although the synchronization signal source is selected with the TRIGGER SLOPE control, the slope cannot be selected. Also you cannot use the PRESET position of the STABILITY Control in this mode.

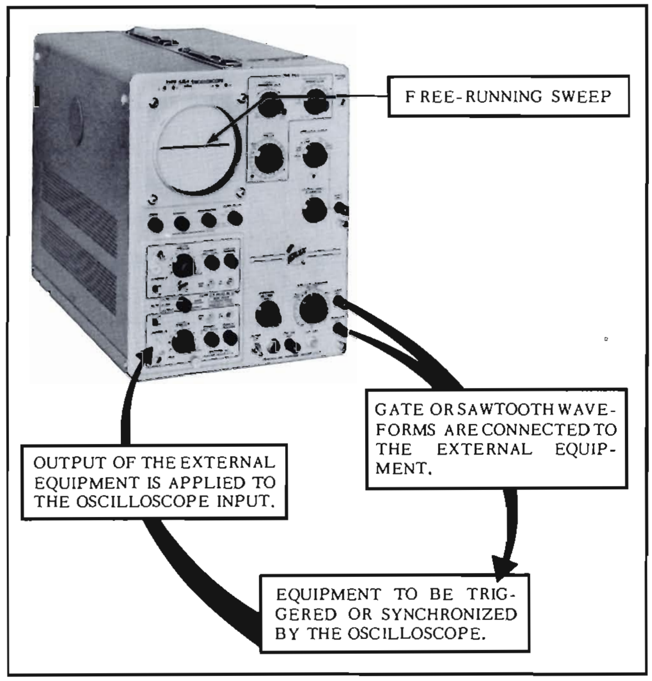


Fig. 2-11. Using the Gate or Sawtooth output waveforms to synchronize or trigger external equipment.

Free-Running Sweep Operation

In the usual oscilloscope application, the sweep is triggered or synchronized by the input waveform. However, in some applications it may be more desirable to reverse the process and initiate the input waveform through use of a periodically recurrent waveform from the oscilloscope. In this type of application the sweep is caused to free-run and an output from either the +GATE OUT or SAWTOOTH connectors is used to trigger or synchronize the input waveform. (See Fig. 2-11).

The sweep can be made to free-run with any setting of the TRIGGERING MODE switch by turning the STABILITY control fully clockwise. In all positions of the TRIGGERING MODE switch except AUTOMATIC the number of sweeps per second is determined by the setting of the TIME/CM controls. In the AUTOMATIC positions, the sweep repetition rate remains at approximately 50 sweeps per second regardless of the setting of the TIME/CM control.

In addition to providing the means of controlling an applied waveform, a free-running sweep also provides a convenient reference trace on the oscilloscope screen without

requiring an input signal. This trace can then be used to position the sweep or to establish a voltage reference line.

Sweep Magnification

To magnify a particular part of a display, position that portion of the display with the HORIZONTAL POSITION controls so that it appears near the center of the graticule. Then turn the HORIZONTAL DISPLAY control to the 5X MAG position. That part of the display which formerly occupied the middle section of the graticule will now be expanded horizontally by a factor of five. The apparent time calibration of the X (sweep) axis will now be equal to the setting of the TIME/CM control divided by the magnification factor.

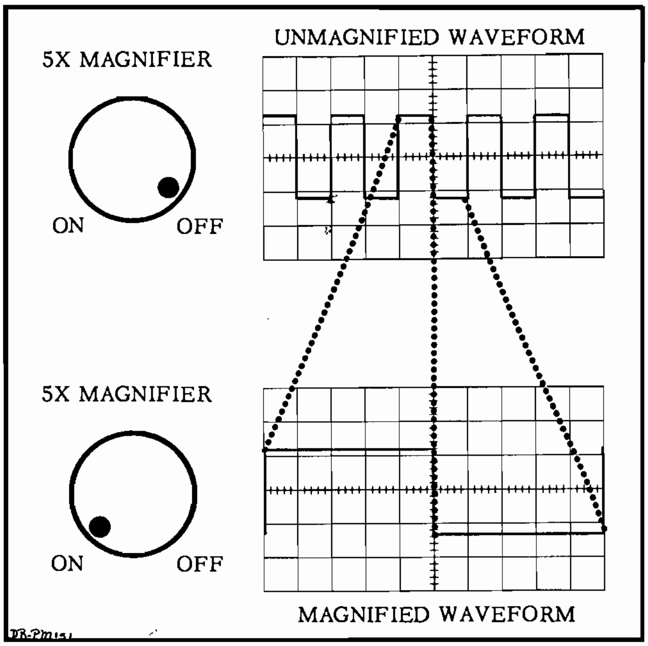


Fig. 2-12. Operation of the sweep magnifier.

External Horizontal Deflection

In some instances it may be necessary to deflect the beam horizontally by means of an externally derived waveform, rather than by means of the internal sweep. To accomplish this, set the HORIZONTAL DISPLAY switch to EXT./HORIZ. ATTEN. and connect the source of the waveform to the EXTERNAL HORIZ. IN connector. Set the EXTERNAL HORIZONTAL controls for the desired amount of horizontal deflection. Two ranges of fixed attenuation (of the external sweep signal) are provided, with a variable control to interpolate between ranges.

Output Waveforms

For certain external applications, the sawtooth sweep waveform is available at the SAWTOOTH OUT connector on the front panel. This positive waveform starts at about ground and rises linearly to a peak amplitude of about 150 volts.

The start and duration of the rising part of the sawtooth coincides with the start and duration of the horizontal sweep on the crt. The rate at which the sawtooth rises is determined by the setting of the TIME/CM control.

A positive rectangular waveform is available at the + GATE OUT connector. This waveform starts at ground and rises to about 20 volts. The starting time and duration of each pulse coincides with starting time and duration of the positive-going part of the sawtooth available at the SAWTOOTH OUT connector.

AUXILIARY FUNCTIONS

Calibrator

The calibrator provides a convenient source of square-waves of known amplitude at a frequency of approximately 1 kc. The square-waves are used primarily to adjust probes and to varify the calibration of the vertical deflection system of the oscilloscope and plug-in unit.

Calibrator square-waves are adjustable from 0.2 millivolt, peak-to-peak, to 100 volts peak-to-peak, in 18 steps. A single AMPLITUDE CALIBRATOR knob controls the full range of 18 outputs.

The peak-to-peak calibrator voltage is within 3 percent of the CALIBRATOR switch setting when the output is connected to a high impedance load.

Dual Trace Displays

The CA Plug-In Unit allows you to obtain two separate traces on the face of the crt. This permits you to display two functions simultaneously. Detailed instructions for operating the Type CA Unit in conjunction with the Type 531A Oscilloscope are contained in the Instruction Manual for the Type CA Unit.

When you are using the Type CA Unit in the chopped mode to obtain a dual-trace presentation, switching transients will be displayed on the screen. You can eliminate these switching transients by placing the CRT CATHODE SELECTOR switch on the rear of the instrument in the DUAL TRACE CHOPPED BLANKING position.

Intensity Modulation

The crt display of the Type 531A Oscilloscope can be intensity modulated by an external signal to display additional information. This is done by disconnecting the grounding bar from the EXTERNAL CRT CATHODE connector at the rear of the instrument and connecting the external signal to this terminal. The CRT CATHODE SELECTOR switch must be in the EXTERNAL CRT CATHODE position.

When you wish to make very accurate time measurements from the crt display, you can intensity modulate the beam with time markers presented on the screen. A positive signal of approximately 25 volts is required to cut off the beam from normal intensity.

Direct Connection to CRT Deflection Plates

The vertical deflection plate pins are located on the side of the crt neck. The horizontal deflection plate pins are

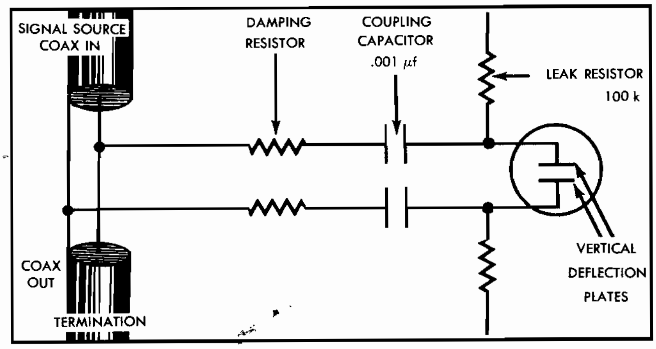


Fig. 2-13. Connecting to the crt deflection plates by AC coupling.

located on the top. In some applications, it is advantageous to connect a signal directly to either one or both sets of these deflection plate pins—bypassing the internal oscilloscope amplifiers. Maintain the average dc voltage on the deflection plates between +275 and +300 volts. If the voltage is not within this range, the crt display becomes defocused.

For dc coupling, it is necessary to supply positioning voltages from the signal source. These voltages should fall within the +275-to +300-volt range. When dc coupling the signal to the deflection plates, you should tape the ends of the wires you have removed from the crt pins. This prevents shorting to the chassis and damage to the amplifier. The external signal source is then connected to the crt pins.

In many applications, it is advantageous to use ac coupling. This is necessary for those signals which cannot be made to have the right dc voltage. Positioning is controlled through the vertical amplifier with its normal positioning control.

The usual direct deflection application is to make use of the ultimate rise-time capability of the crt in the oscilloscope. This requires careful connection to the deflection plates from coaxial cables through damping resistors, and physically small coupling capacitors. These leads should be set close to the crt pins, should be short, and should be rigid. Tie down the coax so that a pull on the coax will not break the crt.

Referring to Fig. 2-13, connect one damping resistor to the coax center conductor. Connect the other damping resistor to the coax outer conductor. The size of the damping resistor will depend upon the coaxial line impedance, the lead lengths, and the coupling capacitor type. The best value is found by passing a fast-rise signal through the coax and adjusting the resistance until the display is just short of overshoot. A good starting value is 68Ω for a 52-Ω coaxial cable. No damping resistors are needed for cables with impedance above approximately 200Ω.

In order to realize the desired amount of deflection sensitivity in the Type T533 Cathode-Ray Tube, the deflection plates have been placed as close as possible to the path of the electron beam. As a result, a small amount of current will flow in the deflection plate circuits. This current flow varies nonlinearly with the beam position, increasing rapidly in that plate toward which the beam is positioned. In the Type 531A Oscilloscope, the effects of these currents are negligible. However, if the resistance is increased, these currents can cause objectionable voltage drops. For values of resistance greater than 110 K for the leak resistor, you may experience some difficulty from the current collected on the deflection plates. Some defocusing or distortion may be evident. These effects are most noticeable when the display is positioned close to the limits of the crt graticule.

The low-frequency response required will determine the size of the coupling capacitor needed. The formula for the size of the coupling capacitor is $C = 1/(2\pi RF)$, where R is the leak resistor, and F is the desired low-frequency cutoff. For example, to find the coupling capacitor needed when the low frequency cutoff is 1600 cps and the leak resistor is 100 K, take the reciprocal of $2\pi RF$. The coupling capacitor is 0.001 μf.

The coupling capacitor should be spaced about ¼" to ⅜" from the damping resistors, and should be of the ceramic disc type, or equivalent, to preserve the fast-rise capability of the Type T533 crt.

To simplify making the direct connection to the crt vertical deflection plates, you can order a plastic plate and mounting bracket from Tektronix, Inc. The mounting bracket is designed to clamp around the neck of the crt shield, adjacent to the deflection plate connections. When mounted correctly, the plate will be accessible through the crt deflection plate access hole in the left side panel. The bracket and plate may be ordered with or without the necessary parts for vertical positioning voltages. Specify part number 013-008 for the blank unit without parts, or part number 013-007 for the wired unit. Holes can be drilled in the plastic plate for mounting coaxial cable and other connectors.

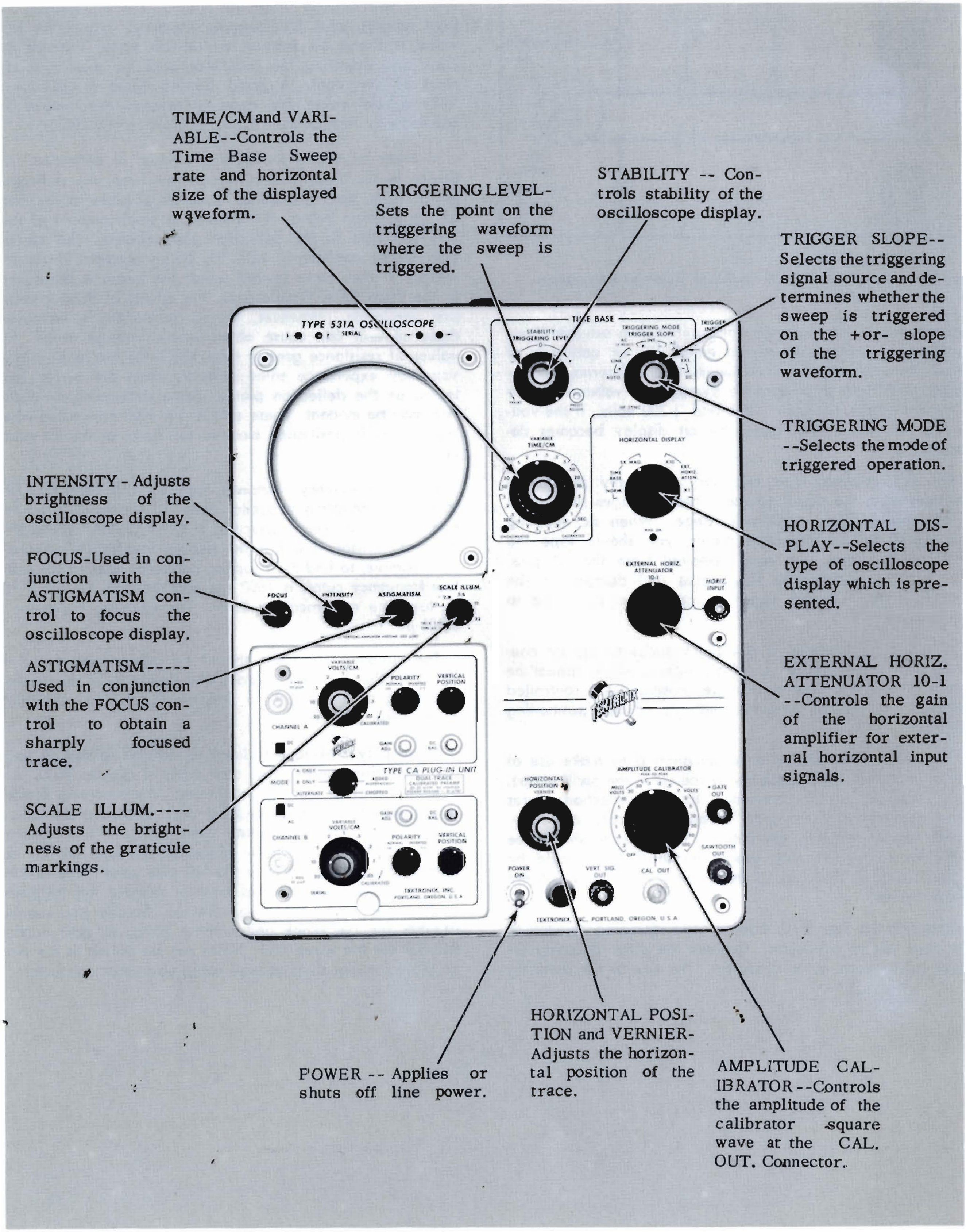
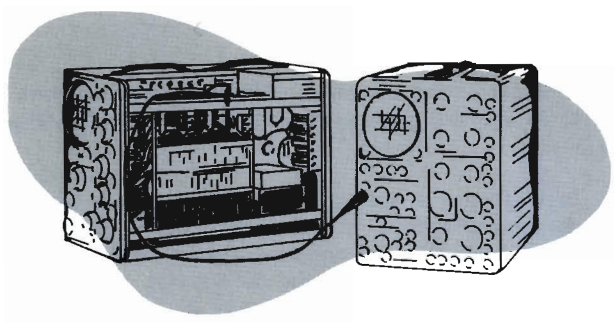


Fig. 2-14. Functions of the Type 531A Oscilloscope front-panel controls.



SECTION 3

APPLICATIONS

Voltage Measurements

The Type 531A Oscilloscope can be used to measure the the voltage of the input waveform by using the calibrated vertical-deflection factors of the instrument and associated plug-in unit. The method used for all voltage measurements is basically the same although the actual techniques vary somewhat depending on the type of voltage measurements required. Essentially there are two types of voltage measurements: ac-component voltage measurements and instantaneous voltage measurements with respect to some reference potential. Many waveforms contain both ac and dc voltage components. It is often necessary to measure one or both of these components.

When making voltage measurements, you should display the waveform over as large a vertical portion of the screen as possible for maximum accuracy. Also it is important that you do not include the width of the trace in your measurements. You should consistently make all measurements from one side of the trace. If the bottom side of the trace is used for one reading, it should be used for all succeeding readings. The VARIABLE VOLTS/CM control must be in the CALIBRATED position.

AC Component Voltage Measurement

To measure the ac component of a waveform, the plug-in unit input selector switch should usually be set to one of the AC positions. In these positions only the ac components of the input waveform are displayed on the oscilloscope screen. However, when the ac component of the input waveform is of very low frequency, it is necessary for you to make voltage measurements with the input selector switch in one of the DC positions to prevent errors.

To make a peak-to-peak voltage measurement on the ac component of a waveform, perform the following steps (see Figure 3-1):

1. With the aid of the graticule, measure the vertical distance in centimeters from the positive peak to the negative peak.

2. Multiply the vertical distance measured by the setting of the plug-in unit VOLTS/CM control to obtain the indicated voltage.

3. Multiply the indicated voltage by the attenuation factor of the probe used to obtain the actual peak-to-peak voltage.

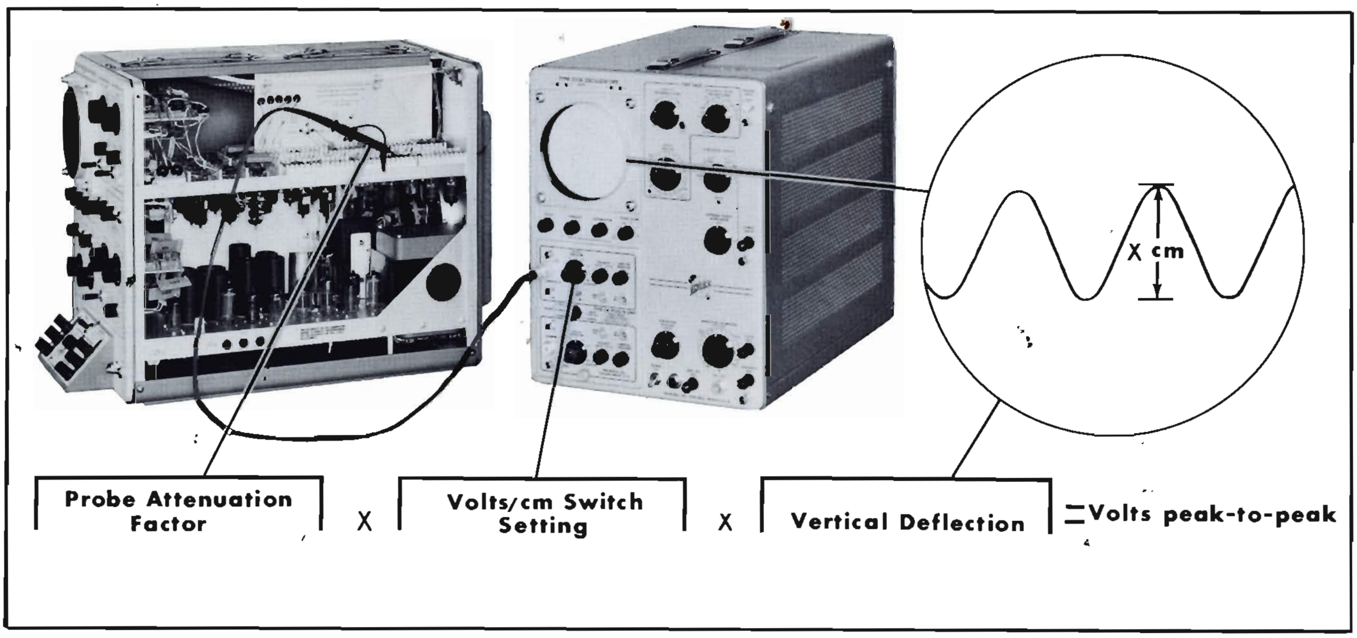


Fig. 3-1. Measuring the peak-to-peak ac component voltage of an applied waveform.

As an example of the method, assume that using a 10X probe and a deflection factor of 1 volt per centimeter, you measure a vertical distance between peaks of 4 centimeters. In this case then, 4 centimeters multiplied by 1 volt per centimeter gives you an indicated voltage of 4 volts peak-to-peak. The indicated voltage multiplied by the probe's attenuation factor of 10 then gives you the true peak-to-peak amplitude of 40 volts.

When sinusoidal waveforms are measured, the peak-to-peak voltage obtained can be converted to peak, rms, or average voltage through use of standard conversion factors.

Instantaneous Voltage Measurements

The method used to measure instantaneous voltage is virtually indentical to the method described previously for the measurements of the ac components of a waveform. However, for instantaneous voltage measurements the plug-in unit input selector switch must be placed in one of the DC positions. Also since instantaneous voltages are measured with respect to some potential (usually ground), a reference line must be established on the oscilloscope screen which corresponds to that potential. If, for example, voltage measurements are to be made with respect to +100 volts, the reference line would correspond to +100 volts. In the following procedure the method is given for establishing this reference line as ground since measurements with respect to ground are by far the most common type. The same general method may be used to measure voltage with respect to any other potential, however, so long as that potential is used to establish the reference line.

To obtain an instantaneous voltage measurement with respect to ground, perform the following steps (see Figure 3-2):

1. To establish the voltage reference line, touch the probe tip to an oscilloscope ground terminal (or if the reference line is to represent a voltage other than ground, to a source of that voltage) and adjust the oscilloscope controls to obtain a free-running sweep. Vertically position the trace to a convenient point on the oscilloscope screen. This point will depend on the polarity and amplitude of the input signal, but should always be chosen so that the trace lies along one of the major divisions of the graticule. The graticule division corresponding to the position of the trace is the voltage reference line and all voltage measurements must be made with respect to this line. (Do not adjust the vertical positioning control after the reference line has been established.)

2. Remove the probe tip from ground and connect it to the signal source. Adjust the triggering control for a stable display.

3. Using the graticule measure the vertical distance in centimeters from the desired point on the waverfom to the voltage reference line.

4. Multiply the setting of the VOLTS/CM control by the distance measured to obtain the indicated voltage.

5. Multiply the indicated voltage by the attenuation factor of the probe you are using to obtain the actual voltage with respect to ground (or other reference voltage).

As an example of this method, assume that you are using a 10X probe and deflection factor of 0.2 volt per centi-

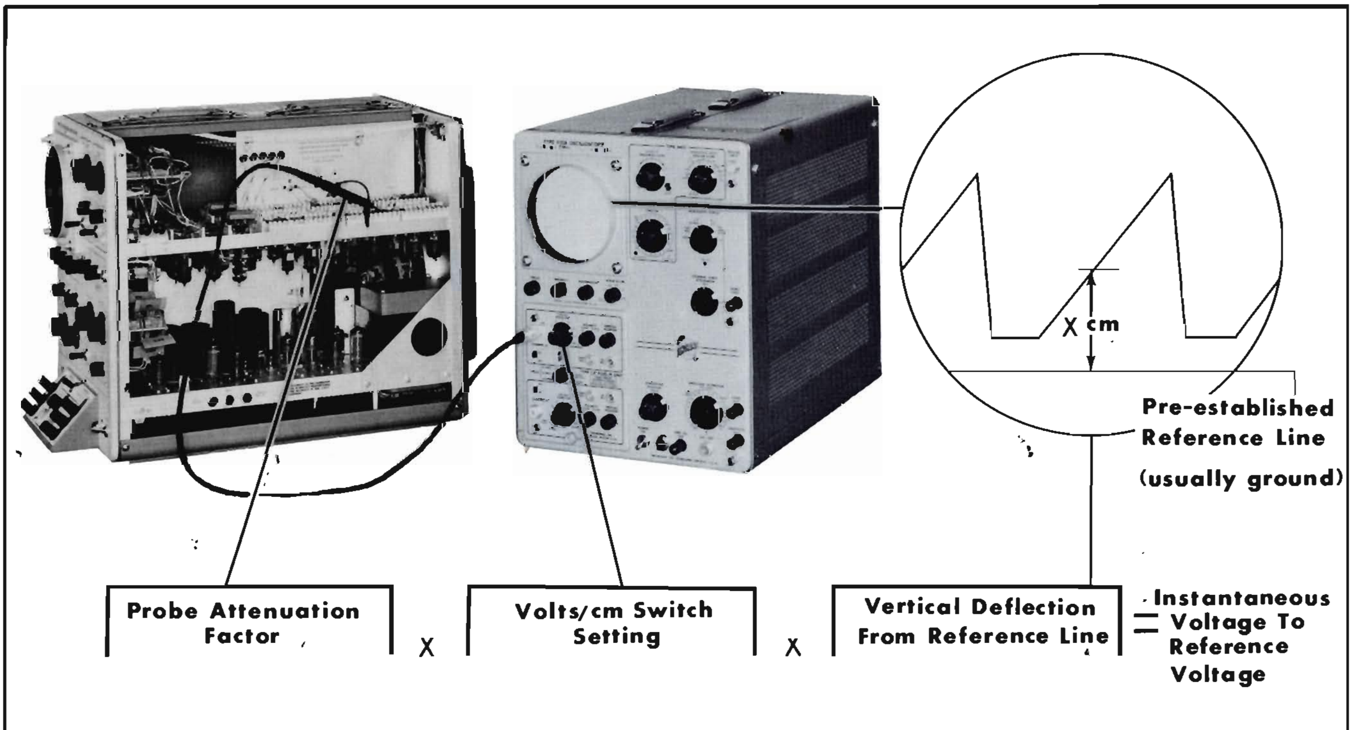


Fig. 3-2. Measuring the instantaneous voltage with respect to ground (or some other reference voltage.)

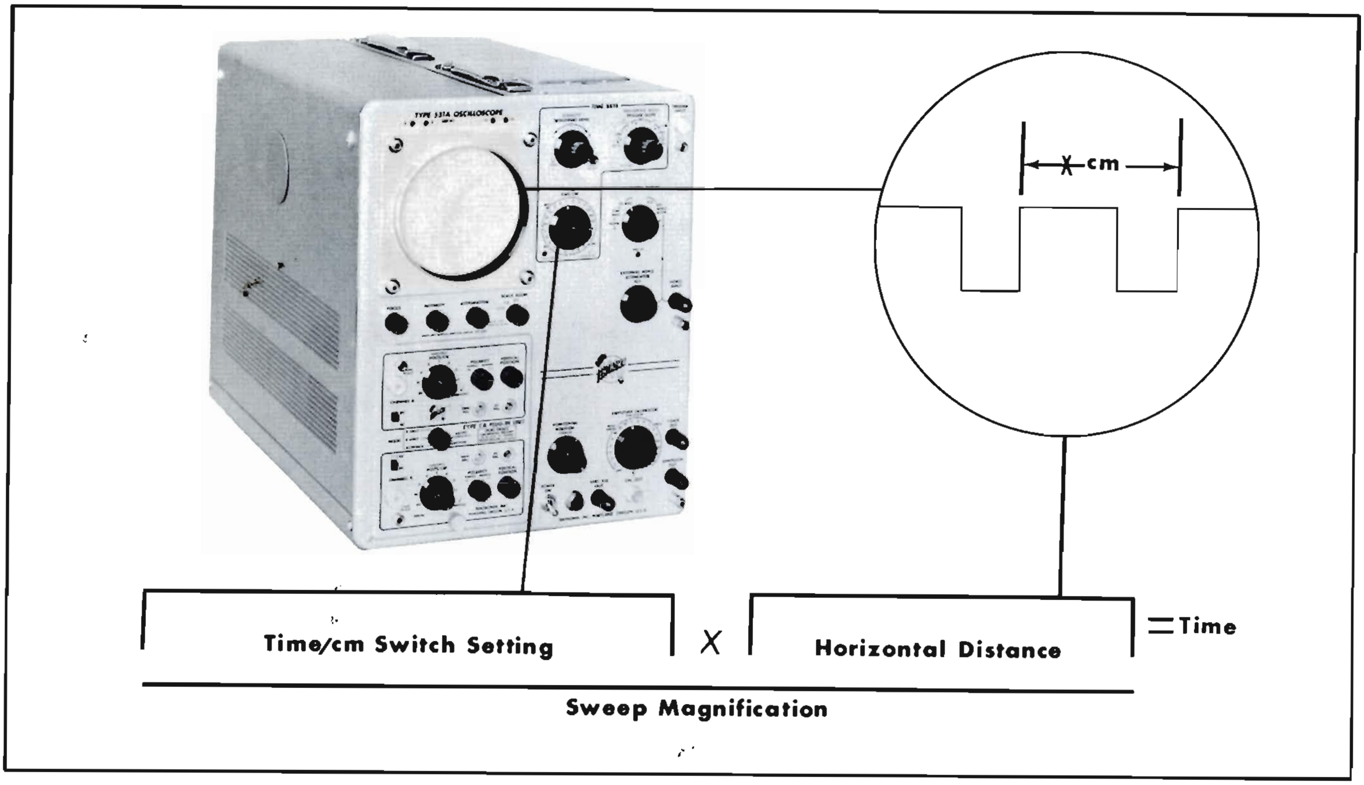


Fig. 3-3. Measuring time interval between events displayed on the oscilloscope screen.

meter. After setting the voltage reference line at the second from the bottom division of the graticule, you measure a distance of 3 centimeters to a point you wish to check. In this case then, 3 centimeters multiplied by 0.2 volt per centimeter gives you an indicated 0.6 volt. Since the voltage point is above the voltage reference line, the polarity is indicated to be positive. The indicated voltage multiplied by the probe's attenuation factor of 10 then gives you the actual voltage of positive 6 volts.

Time Measurements

The calibrated sweeps of the Type 531A Oscilloscopes cause any horizontal distance on the screen to represent a definite known interval of time. Using this feature you can accurately measure the time lapse between two events displayed on the oscilloscope screen. This is done by the following method:

1. Using the graticule, measure the horizontal distance between the two displayed events whose time interval you wish to find.

2. Multiply the distance measured by the setting of the TIME/CM control to obtain the apparent time interval. (The VARIABLE TIME/CM control must be in the CALIBRATED position.)

3. Divide the apparent time interval by the setting of the MAGNIFIER control if the magnifier is on, and 1 if the magnifier is off, to obtain the actual time interval.

For example, assume that the TIME/CM switch setting is 1 MILLISEC, the magnifier is on, and that you measure a horizontal distance of 5 centimeters multiplied by 1 millisecond per centimeter gives you an apparent time interval of 5 milliseconds. The apparent time divided by 5 then gives you the actual time interval of 1 millisecond.

Frequency Measurements

Using the methods described in the previous section, you can measure the period (time required for one cycle) of a recurrent waveform. The frequency of the waveform can then easily be calculated since frequency is the reciprocal of the period. For example, if the period of a recurrent waveform is accurately measured and found to be 0.2 microsecond, the frequency is the reciprocal of 0.2 microsecond, or 5 mc.

At any given oscilloscope sweep rate, the number of cycles of the input waveform that is displayed on 10 centimeters of the screen is dependent on the frequency of the input waveform. Frequencies can usually be measured faster by the following method than by the one given in the last paragraph.

If you divide the cycles per unit of length by the time required for the input waveform to sweep this unit of length, you get the frequency. The total number of cycles are found for 10 cm for greater accuracy. Since the TIME/CM switch gives time for 1 cm, multiply this setting by 10 to have the time required for 10 cm. (See Fig. 3-4).

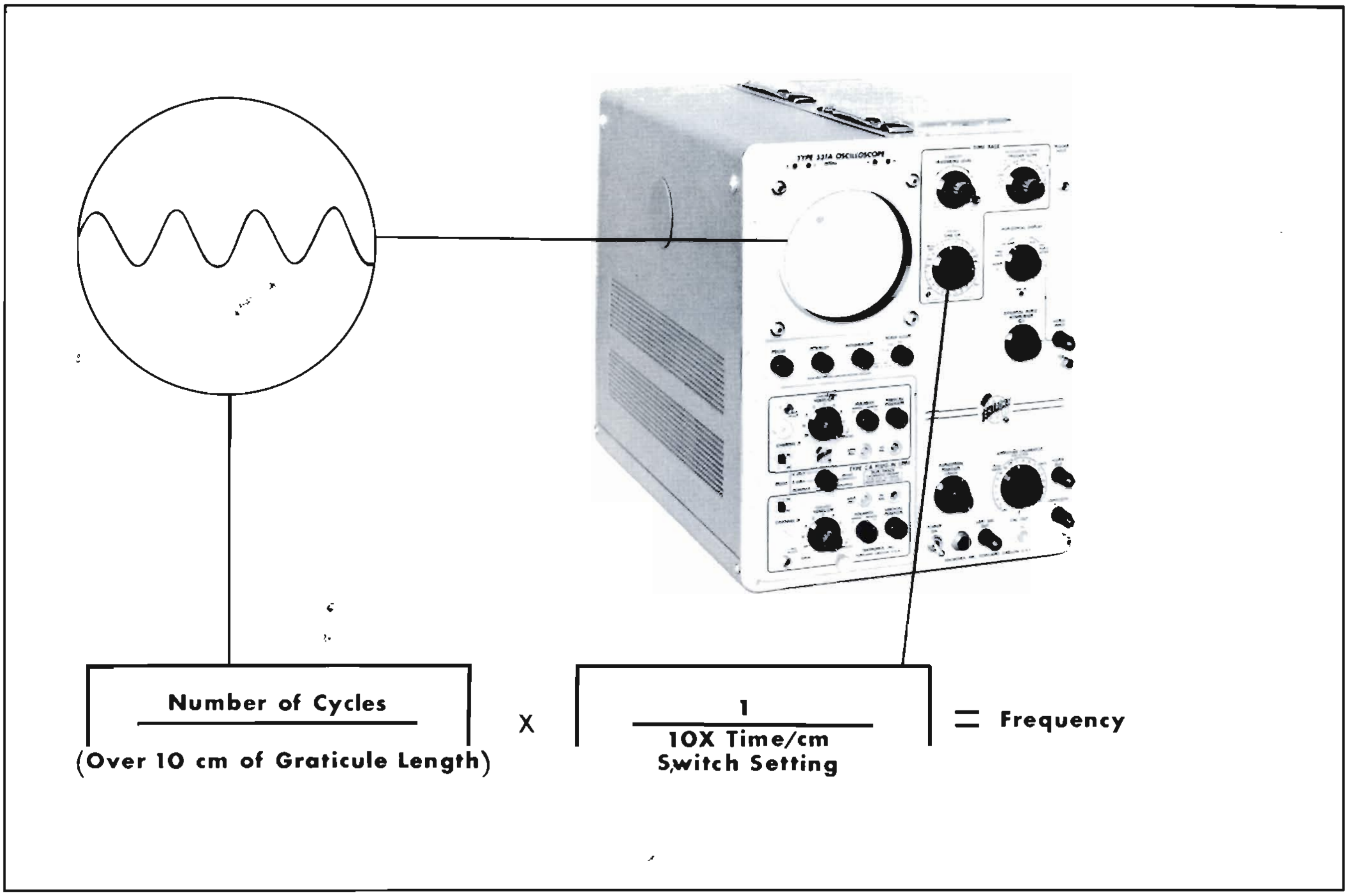


Fig. 3-4. Measuring the frequency of a repetitive input signal.

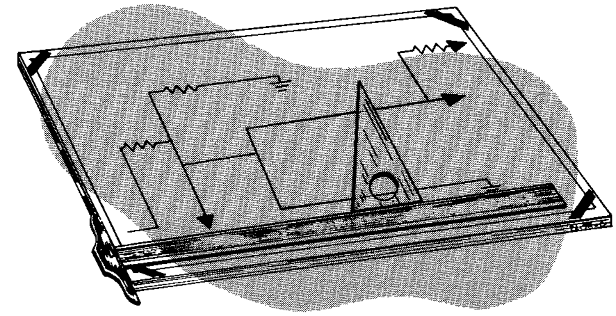
To obtain the frequency of a repetitive input signal, perform the following steps:

1. Adjust the TIME/CM control to display several cycles of the input waveform. Insure that the VARIABLE TIME/CM control is in the CALIBRATED position.

2. Count the number of cycles of the waveform shown on the 10 centimeters of the graticule.

3. Divide this number by 10 times the TIME/CM switch setting. This gives you the frequency of the input waveform.

For example, assume that when you are using a sweep rate of 50 milliseconds per centimeter, you count 7.2 cycles in 10 centimeters. The frequency is 7.2 cycles divided by 50 milliseconds times 10, or 500 milliseconds. 500 milliseconds are 500 x 0.001 second, or 0.5 second. 7.2 cycles per ½ a second gives you 14.4 per second.



SECTION 4

CIRCUIT DESCRIPTION

VERTICAL DEFLECTION SYSTEM

General

The dc-coupled, push-pull, main Vertical Amplifier provides the necessary gain to drive the Delay Line and the vertical deflection plates of the crt. The main units of the Vertical Amplifier are the Input Amplifier Stage V504 and V524; the C.F. Driver Stage, V533B and V543B and the Output Amplifier Stage, V544 and V564. Other circuits of importance include the Trigger Pickoff Amplifier, V584A and V584B, the Indicator Amplifiers, V533A and V543A, and the lamps, B536 and B546.

Input Circuit

The signal input from the plug-in unit is coupled through terminals 1 and 3 of the inter-connecting plug to the grids of the Input Amplifiers, V504 and V524. The plate circuit of this stage is compensated for both high-frequency attenuation and dc shift.

High-frequency compensation is provided by the series-shunt peaking coils, L506 and L523. These coils extend the bandwidth of the amplifier by reducing the high-frequency attenuation caused by tube and stray capacitance in the circuit. Additional high-frequency compensation is provided by L526 and L541.

DC shift in the amplifier tubes—a condition whereby the dc (and extremely low-frequency) transconductance is less than at mid-frequencies—is compensated by an ac "boost" network. R507 and C507A in the plate circuit of V504, and R524 and C507B in the plate circuit of V524, shunt the plate load resistors in each circuit. The time constant of the circuit is such that the plate load resistance is 1.6 k in the range from dc to a fraction of a cycle, but reduces to 1.5 k for high frequencies. The slightly higher plate load resistance, in the range from dc to a fraction of a cycle compensates for the slightly reduced transconductance of the tubes in this range. As a result, the gain remains substantially constant from dc to the upper limit of the amplifier.

The Input Amplifiers are coupled to the Output Amplifiers through the Cathode Follower Drivers, V533B and V543B. These Drivers isolate the Input Amplifiers from the Output Amplifiers, V544 and V564.

Output Circuit

The Output Amplifiers, V554 and V564, are the driving source for the Delay Line and the vertical deflection plates of the crt. The gain of this stage is set by means of R570, the GAIN ADJ. control. The GAIN ADJ. control varies the degeneration in the cathode circuit. When this control is adjusted properly, and the VARIABLE control is in the CALIBRATED position, the vertical deflection on the CRT agrees with the deflection factor on the plug-in unit.

High-frequency compensation is provided by the series-shunt peaking coils, L553 and L563. Like the peaking coils in the input circuit, they also extend the bandwidth of the amplifier by reducing high-frequency attenuation caused by stray and tube capacitance in the circuit.

The plate load resistors for the Output Amplifiers are R553 and R563. They are also the terminating resistors for the Delay Lines.

The vertical signal is delayed $\frac{1}{4}$ microsecond between the input of the Delay Line and the vertical deflection plates.

Beam Position Indicators

The beam-position indicators, B536 and B546, are located on the front panel above the crt. They indicate the relative vertical position of the trace with respect to the center of the graticule. When the beam is centered vertically, the potential across either neon is insufficient to light it. As the beam is positioned up or down the screen, the current through the Indicator Amplifiers (and hence the voltage across the neons) will change. The voltage across one neon will increase, causing it to light. The voltage across the other will decrease, causing it to remain extinguished. The arrow nearest the lighted neon indicates the direction of the beam.

Trigger Pickoff

When internal triggering of the Time Base Generator is desired (black TRIGGER SLOPE knob is either in the + or — INT. position), a "sample" of the vertical signal is used to develop the triggering pulse. This "pulse" is obtained from the trigger pickoff circuit consisting of the Trigger Pickoff Amplifier V584A and 584B, and Trigger Pickoff Cathode Follower V593A.

This "sample" of the Vertical signal is also ac-coupled through Vertical Signal Out C.F. V593B and C599 to a front-panel binding post labeled VERT. SIG. OUT.

Delay Line

The output signal from the Vertical Amplifier is coupled through the balanced Delay Line to the vertical deflection

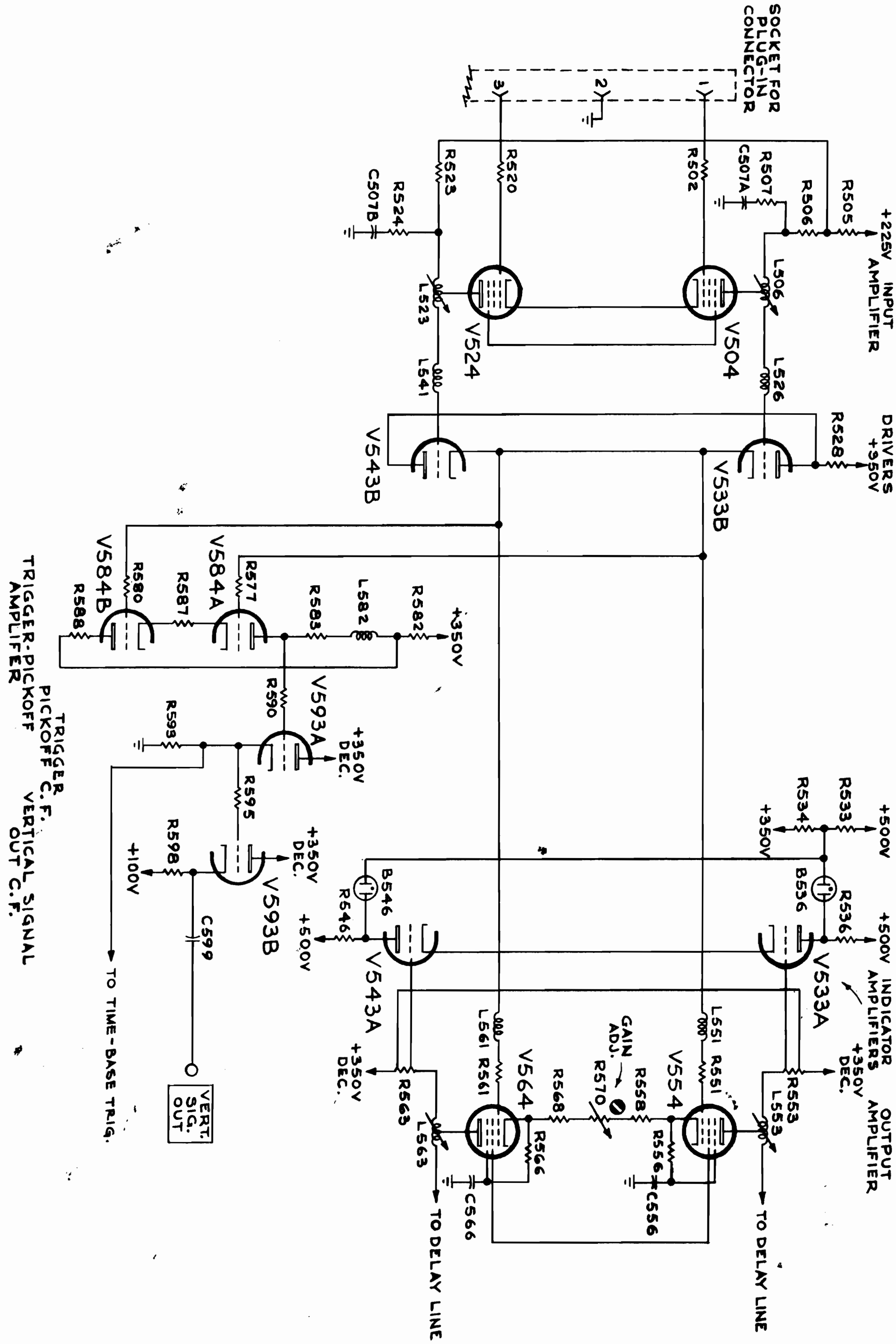


Fig. 4-1. Simplified Type 531A Vertical Amplifier Circuitry.

plates of the crt. The function of the Delay Line is to retard the arrival of the waveform at the deflection plates until the crt has been unblanked and the horizontal sweep has started. This delay, as mentioned, insures that the very "front" of fast vertical signals can be observed. The line is adjusted by means of the variable capacitors connected across the line, for optimum transient response.

HORIZONTAL DEFLECTION SYSTEM

Time-Base Trigger

General

The Time-Base Trigger develops a pulse which will initiate a cycle of action in the Time-Base Generator. To display signals below five megacycles, a TRIGGERING MODE switch allows the operator to select the type of triggered operation most suitable for the waveform to be displayed. A second switch, the TRIGGER SLOPE switch, allows the operator to select the "slope", either positive or negative, which will cause triggered operation of the sweep. To display signals above five megacycles, the Time-Base Trigger is bypassed, and the signal is applied to the Sweep-Gating Multivibrator in the Time-Base Generator. No choice of triggering slope is available in this mode.

Trigger Input Amplifier

Triggering signals may be developed from several sources. The most common source of triggering signals utilizes the internal circuitry of the oscilloscope to sample the signal preset in the vertical amplifier. Using an internal source of triggering signal, either triggered operation in the various triggering modes, or synchronized operation, is available.

Triggered or synchronized operation of the time-base circuitry may also be affected from an external source. Operation in any of the available modes is possible with external signals.

In the +Line or —Line positions of the TRIGGER SLOPE switch a voltage at the power line frequency is used to develop the triggering signal.

The Trigger-Input Amplifier is a polarity-inverting, cathode-coupled amplifier. It serves two basic-functions in the Time-Base Trigger. First, it provides a source of negative-going signal to drive the following stage. Secondly, by means of the TRIGGERING LEVEL control, it enables the operator to select the signal level at which triggered operation of the Time-Base will occur.

To trigger from a negative-going signal, the grid of the V24A section is connected to the input signal source. The grid of the V24B section is connected to a dc bias source, which is adjustable with the TRIGGERING LEVEL control. This bias voltage establishes the voltage present at the plate under no-signal conditions.

The voltage at the grid of V24A and the voltage at the plate of V24B are in phase with each other; that is, they both go through ac zero in the same direction at the same time. Thus, the V24A section acts as a cathode-follower, and the signal voltage developed across the cathode resistor becomes the input signal to the V24B section.

To trigger from a positive-going signal, the grid of the V24A section is connected to the TRIGGERING LEVEL control, and the grid of the V24B section is connected to the input signal. With this configuration, the voltage at the plate of the V24B section will be 180 degrees out of phase with the input-signal voltage.

In each of the cases outlined above, a negative-going signal is produced at the plate of the V24B section of the Trigger-Input Amplifier irrespective of the polarity of the input signal.

Also, the amplitude of the triggering signal necessary to cause operation of the following stage is determined by the setting of the TRIGGERING LEVEL control.

Trigger Multivibrator

The Trigger Multivibrator is a dc-coupled multivibrator. In the quiescent state, ready to receive a signal, the V45A section is conducting and the plate voltage is down. Since the plate is dc-coupled to the grid of the V45B section that grid is held below cutoff. With the V45B section cut off its plate voltage is up and no output is developed.

The negative-going portion of the signal from the Trigger-Input Amplifier is required to drive the grid of the V45A section down. As the V45A section grid is driven negative, the current flow through the tube is restricted and the voltage at the plate starts to rise.

The rise in voltage at the plate of the V45A section carries the grid of the V45B section in the positive direction.

The cathodes of both sections are coupled together, and follow the action of the grids. With the V45B section grid going in a positive direction, and the cathode in a negative direction, the V45B section starts to conduct. As the V45B section starts to conduct, the cathodes of both sections follow the action of the V45B section grid; hence the cathode voltage starts to rise.

As the V45A section grid goes down and its cathode goes up it stops conducting. As the V45B section conducts, its plate voltage drops, creating a negative step at the output. This transition occurs rapidly, regardless of how slowly the V45A grid falls.

When the signal applied to the grid of the V45A section goes in a positive direction the action described in the previous paragraphs reverses itself. That is, the V45A section will start to conduct once more, while the V45B section will be cut off.

In the AUTO. position of the TRIGGERING MODE switch the Trigger Multivibrator is converted from a bistable configuration to a recurrent configuration. This is accomplished by coupling the grid circuit of the V45A section to the grid circuit of the V45B section. In addition, the ac coupling between the grid of the V45A section of the Trigger Multivibrator and the plate of the V24B section of the Trigger-Input Amplifier is replaced by dc coupling.

In the AUTO. triggering mode the Trigger Multivibrator will free run in the absence of a trigger signal. For example, assume that the grid of the V45A section is just be-

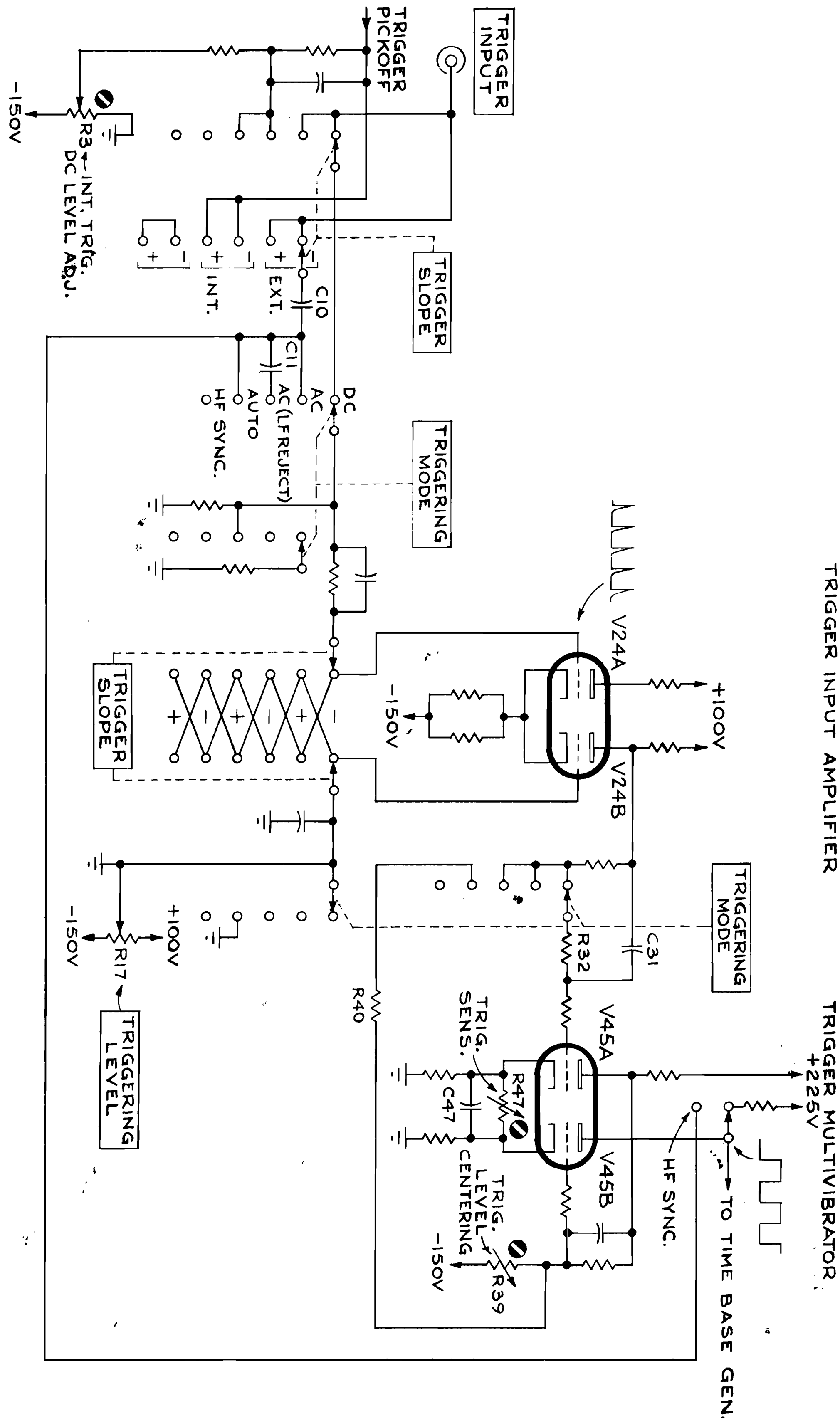


Fig. 4-2. Simplified Type 531A Trigger Circuitry.

ing driven into cutoff. The voltage at the plate of the V45A section starts to rise, carrying with it the grid of the V45B section. As the voltage at the grid of the V45B section starts to rise, the V45B section starts to conduct.

The rising voltage at the grid of the V45B section is coupled to the grid of the V45A section through R41. The grid of V45A is prevented from rising immediately by the action of C31, which must be charged sufficiently to rise the voltage at the grid of the V45A section above cutoff.

As the V45A section starts to conduct, its plate voltage drops, which in turn lowers the voltage at the grid of the V45B section. The voltage at the grid of V45A starts dropping exponentially toward cutoff. When the V45A section reaches cutoff, the circuit has completed one cycle of an approximately 50-cycle repetition rate.

The Trigger Multivibrator produces a square-wave which is coupled to the Time-Base Generator. This square wave is differentiated in the Time-Base Generator to produce a sharp, negative-going pulse which is used to trigger the Time-Base Generator in the proper time sequence when triggered operation is desired. For synchronized operation of the Time-Base Generator, the TRIGGER MODE Switch is placed in the HF SYNC position. This couples the signal present at the input of the Time-Base Trigger directly into the Time-Base Generator, and the Time-Base Trigger circuitry is not used in the HF SYNC mode.

Time-Base Generator

General

The Trigger circuit produces a negative-going waveform which is coupled to the Time-Base Generator. This waveform is differentiated in the grid circuit of V135A to produce a sharp negative-going triggering pulse to trigger the Time-Base Generator in the proper time sequence. Positive-going pulses are also produced in the differentiation process, but they are not used in the operation of the Time-Base Generator.

The Time-Base Generator consists of three main circuits; a Sweep-Gating Multivibrator, a Miller Runup Circuit, and a Holdoff Circuit. The Sweep-Gating Multivibrator consists of V135A, V145 and the cathode follower V135B. The essential components of the Miller Runup circuits are the Miller Tube V161, the Runup C.F. V173, the On-Off Diodes V152, the Timing Capacitor C160 and the Timing Resistor R160. The Holdoff circuit consists of the Hold-Off C.F.'s V183A-V133B, the Holdoff Capacitor C180 and the Holdoff Resistors R181-R180. Essential circuitry of the Time-Base Generator is shown in Fig. 4-3.

Sweep-Gating Multivibrator

The Sweep-Gating Multivibrator operates as a bistable circuit. In the quiescent state V135A is conducting and its plate is down. This cuts off V145 through V135B and the divider R141-R143, and the common cathode resistor R144. With V145 cut off, its plate is clamped about 3 volts below ground by the conduction of diodes V152A and B through R147 and R148. Conduction of the lower diodes V152B through the Timing Resistor R160 then clamps the grid of the Miller tube at about —3.5 volts.

Miller Runup Circuit

The quiescent state of the Miller circuit is determined by a dc network between plate and grid. This network consists of the neon glow tube B167, the Runup CF V173 and the On-Off Diodes V152. The purpose of this network is to establish a voltage at the plate of the Miller tube of such a value that the tube will operate above the knee, and thus over the linear region, of its characteristic curve. This quiescent plate voltage is about +43 volts.

Sweep Generation

If the STABILITY and TRIGGERING LEVEL controls are now adjusted for triggered operation, a negative trigger will drive the grid of V135A below cutoff and force the Sweep-Gating Multivibrator into its other state in which V145 is the conducting tube. As V145 conducts its plate drops, cutting off the On-Off Diodes V152. Any spiking that may occur during this transition is attenuated by the C150-R150 network.

With V152 cut off the grid of the Miller tube and the cathode of the Runup CF are free to seek their own voltages. The grid of the Miller tube then starts to drop, since it is connected to the —150-volt bus through the Timing Resistor R160. The plate of the Miller tube starts to rise, carrying with it the grid and cathode of V173. This raises the voltage at the top of the Timing Capacitor C160, which in turn pulls up the grid of the Miller tube and prevents it from dropping. The gain of the Miller tube, as a Class A amplifier, is so high that the voltage coupled back through C160 keeps the grid constant within a fraction of a volt.

The Timing Capacitor then starts charging with current from the —150-volt bus. This charging current flows through the Timing Resistor R160. Since the voltage at the grid of the Miller tube remains essentially constant the voltage drop across the Timing Resistor remains essentially constant. This provides a constant source of current for charging C160. By this action C160 charges linearly, and the voltage at the cathode of V173 rises linearly. Any departure from a linear rise in voltage at this point will produce a change in the voltage at the grid of the Miller tube in a direction to correct for the error.

Timing Switch

The linear rise in voltage at the cathode of V173 is used at the sweep time-base. Timing Capacitor C160 and Timing Resistor R160 are selected by the TIME/CM switch SW160. R160 determines the current that charges C160. By means of the TIME/CM switch both the size of the capacitor being charged and the charging current can be selected to cover a wide range of sawtooth slopes (sweep rates). For high speed sweeps bootstrap capacitor C165 helps supply current to charge the strap capacitance at the plate of the Miller tube, this permits the plate voltage to rise at the required rate.

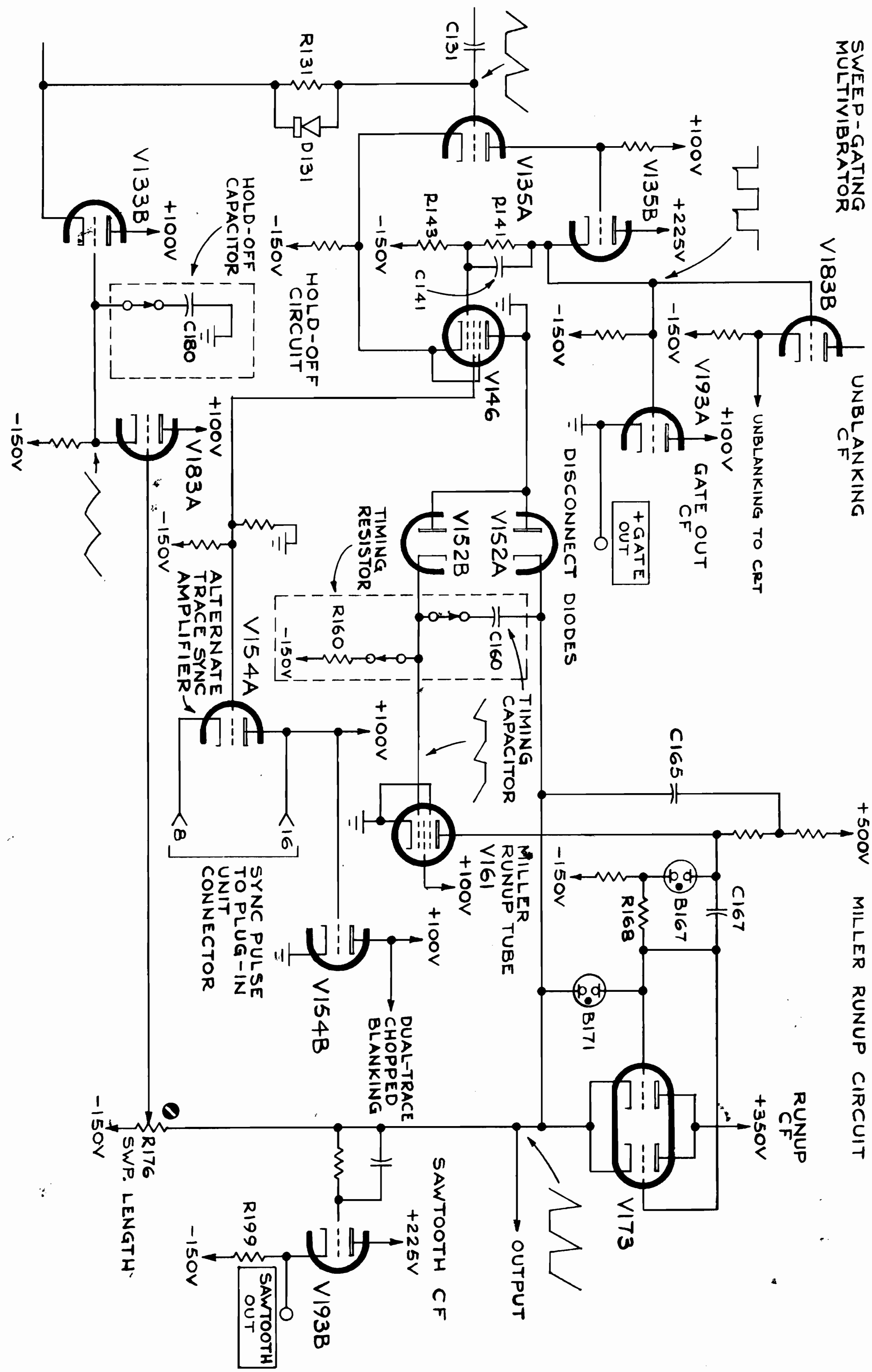


Fig. 4-3. Simplified Type 531A Time-Base Generator Circuit.

If uncalibrated sweep rates are desired, the VARIABLE TIME/CM (red knob) control may be turned away from the CALIBRATED position. This control, R160Y, varies the sweep rate over a $2^1/_2$ to one range. Switch 160B is ganged with the VARIABLE control in such a way that the UNCALIBRATED light comes on when the control is turned away from the CALIBRATED position.

Sweep Length

As explained previously, the sweep rate (the rate at which the spot moves across the face of the crt) is determined by the timing circuit C160 and R160. The length of the sweep (the distance the spot moves across the face of the crt), however, is determined by the setting of the SWP. LENGTH control R176. This will increase the voltage at the grid and cathode of V183A and at the grid and cathode of V133B. As the voltage at the cathode of V133B rises, the voltage at the grid of V135A will rise. When the voltage at this point is sufficient to bring V135A out of cutoff, the multivibrator circuit will rapidly revert to its orginal state with V135A conducting and V145 cut off. The voltage at the plate of V145 rises, carrying with it the voltage at the diode plate V152A. The diode then conducts and provides a discharge path for C160 through R147 and R148 and through the resistance of the cathode circuit of V173. The plate voltage of the Miller tube now falls linearly, under feedback conditions essentially the same as when it generated the sweep portion of the waveform except for a reversal of direction. The resistance through which C160 discharges is much less than that of the timing resistor (through which it charges). The capacitor current for this period will therefore be much larger than during the sweep portion, and the plate of the Miller tube will return rapidly to its quiescent voltage. This produces the retrace of the sweep sawtooth during which time the crt beam returns rapidly to its starting point.

Holdoff

The Holdoff Circuit prevents the Time-Base Generator from being triggered during the retrace interval. That is, the Holdoff allows a definite time for the Time-Base circuits to regain a state of equilibrium after the completion of a sweep.

During the trace portion of the sweep sawtooth, the Holdoff Capacitor C180 charges through V183A, as a result of the rise in voltage at the cathode of V183A. At the same time the grid of V135A is being pulled up, through V133B, until V135A comes out of cutoff and starts conducting. As mentioned previously, this is the action that initiates the retrace. At the start of the retrace interval C180 starts discharging through the Holdoff Resistor R181. The time constant of this circuit is long enough, however, so that during the retrace interval (and for a short period of time after the completion of the retrace) C180 holds the grid of V135A high enough so that it cannot be triggered. However, when C180 discharges to the point where V133B is cut off, it loses control over the grid of V135A and this grid returns to the level established by the STABILITY control. The holdoff time required is determined by the size of the Timing Capacitor. For this reason the TIME/CM switch changes the time constant of the Holdoff Circuit simultaneously with the change of Timing Capacitors. (In the μSEC positions of the TIME/CM switch R181 is shunted by either R180A or R180B, shown on the Timing Switch diagram.)

Stability

The operational mode of the Time-Base Generator is determined by the setting of the STABILITY control R110. By means of this control the sweep can be turned off, adjusted for triggered operation, or adjusted for free-running operation. The STABILITY control, through cathode follower V133A, regulates the grid level of V135A.

For triggered operation, the STABILITY control is adjusted so that the grid of V135A is just high enough to prevent the Sweep-Gating Multivibrator from free-running. Adjusted in this manner a sweep can only be produced when an incoming negative trigger pulse drives the grid of V135A below cutoff.

Moving the arm of the STABILITY control toward ground (ccw rotation), but not so far as to actuate the PRESET switch, will raise the grid level of V135A and prevent the Sweep-Gating Multivibrator from being triggered. This action turns off the sweep. Moving the arm toward —150 volts drop the grid of V135A to the point where the discarge of the Holdoff Capacitor C180 can switch the multi. Adjusted in this manner, the Sweep-Gating Multivibrator will free-run and produce a recurrent sweep.

When the STABILITY control is turned full ccw to the PRESET position, R110 is switched out of the circuit and R111 is switched in. This control, a front-panel screwdriver adjustment labeled PRESET ADJUST, provides a fixed dc voltage for the grid of V135A. When properly adjusted, PRESET operation can be used for most triggering applications. Where triggering may be difficult, however, the manual STABILITY control R110 should be used.

Unblanking

The positive rectangular pulse at the cathode of V135B in the Sweep-Gating Multivibrator circuit, is coupled through a cathode follower V183B to the grid supply for the crt. This pulse, whose start and duration are coincident with the rising portion of the sawtooth sweep waveform, pulls up the grid of the crt. This unblanks the crt during the trace portion of the sweep and permits the trace to be observed.

Output Waveforms

The positive pulse coupled to the crt circuit for unblanking is also coupled through a cathode follower V193A to a front-panel binding post labeled +GATE OUT. This positive gate waveform starts at ground and rises to about +20 volts.

The sweep sawtooth voltage at the cathode of V173 is coupled through a cathode follower V193B to a front-panel binding post labeled SAWTOOTH OUT. This waveform, which starts about ground, provides a 150-volt rise linear in voltage.

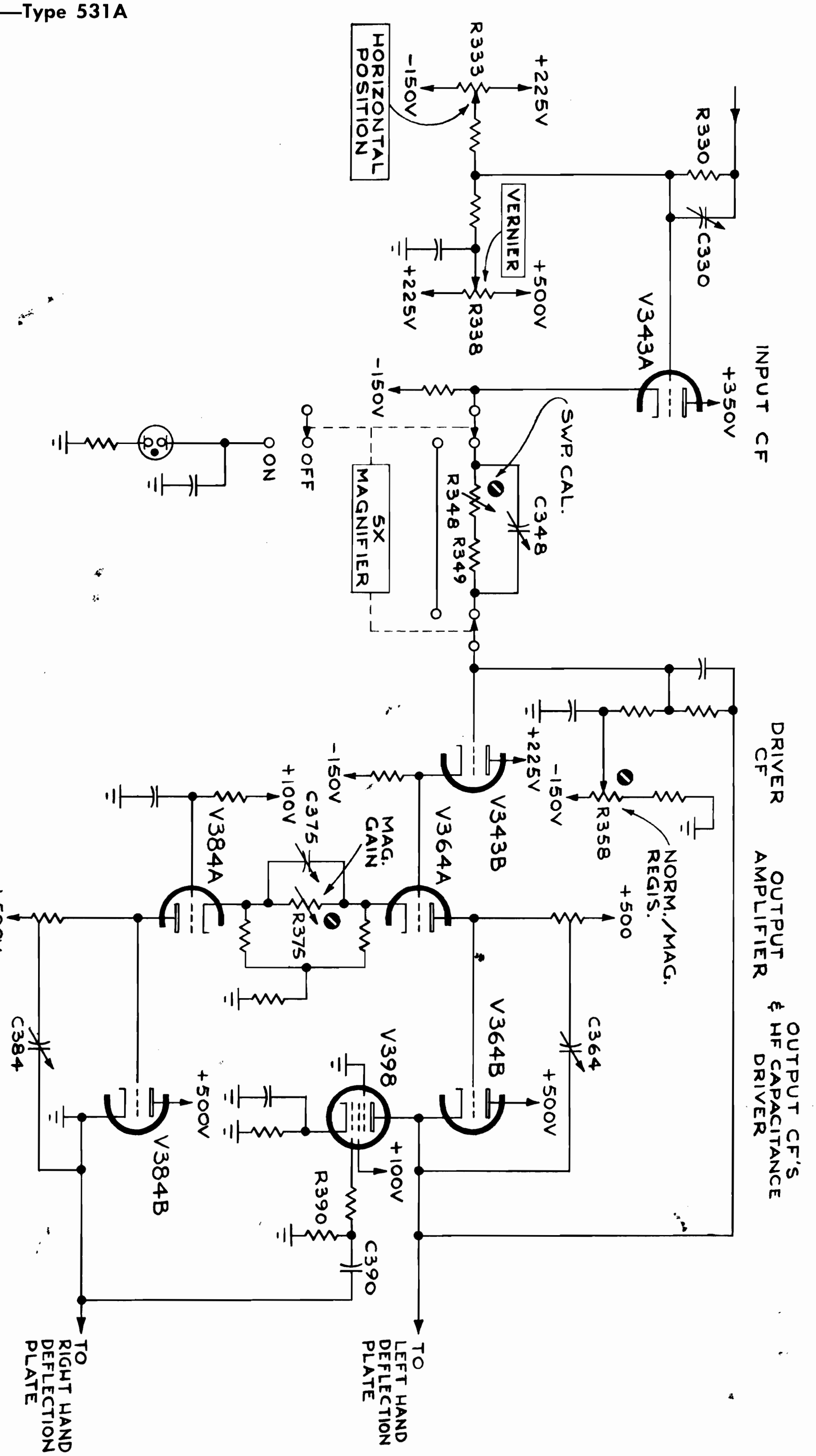


Fig. 4-4. Simplified Type 531A Horizontal Amplifier.

Dual-Trace Sync and Blanking

Synchronizing pulses for dual-trace plug-in preamplifiers are suppiled by V154A. When multivibrator tube V145 cuts off, a sharply differentiated positive pulse is developed at its screen. This pulse, coupled to the grid of V154A, produces a negative trigger at the plate of V154A. This trigger then switches the multivibrator in the dual-trace unit employed for alternate sweeps.

When the dual-trace multivibrator is connected for free-running operation to produce chopped sweeps, a negative pulse is coupled from the multi to the grid of V154B. The resultant positive pulse at the plate of V154B is coupled to the cathode of the crt to blank out the beam during switching. Refer to the manual for the dual-trace unit for a detailed description of the switching multi.

HORIZONTAL AMPLIFIER

The Horizontal Amplifier converts the single-ended sawtooth output of the Time-Base Generator into push-pull signal suitable for driving the horizontal plates of the crt. The gain of the amplifier may be varied by a factor of five by means of the 5X magnification switching. In addition, controls are provided for horizontal positioning and adjustment of the horizontal linearity.

Input Circuit

The sawtooth waveform from the Time-Base Generator is coupled to the Input Cathode Follower through the R330, C330 network. This network attenuates the input signal and provides a means of compensating the input circuitry for optimum frequency response. During calibration C330 is adjusted for best response to a square wave.

The HORIZONTAL POSITION and VERNIER controls adjust the dc level at the grid of V343A. This change in dc level changes the dc level on the signal path through the amplifier, thus changing the dc voltage applied to the crt horizontal deflection plates and affecting the horizontal positioning.

Input Amplifier

Coupling between the Input CF and the Driver CF is made by the 5X MAG position of the HORIZONTAL DISPLAY switch. When this switch is not in the 5X MAG position the signal from the Input CF must pass through the network formed by C348 in parallel with the series combination R348 and R349. R348, a variable resistor, allows the operator to adjust the length of the time base by varying the attenuation applied to the signal. C348, a variable capacitor, is adjusted to provide optimum linearity of the time base on the fastest time bases.

This network attenuates the signal by a factor of five. To provide magnification of the time base, the network is removed when the HORIZONTAL DISPLAY switch is turned to the 5X MAG position.

The gain of the Horizontal Amplifier is controlled by a negative-feedback circuit. The signal appearing at the left-hand deflection plate is fed back to the input of the Driver CF. R358 is an adjustable resistor which allows the operator to vary the dc voltage applied to the feedback loop.

By changing the dc voltage at this point the opeartor can adjust the position of the unmagnified sweep so that it will correspond with the position of the magnfied sweep.

The output waveform from the Horizontal Amplifier is taken from V364A and V384A. The cathodes of these tubes are connected through a network which includes the Mag. Gain control. This control enables the operator to adjust the gain of the Horizontal Amplifier so that the ratio between the magnified and unmagnified sweeps is correct. C375, in parallel with the Mag. Gain control, has considerable effect on the linearity at the beginning of the time base, and is adjusted while displaying a signal with a high repetition rate.

Part of the signal appearing at the plates of the output amplifiers is used to drive the Output CFs. Note that the cathode of V364B is connected to the plate of V398, a pentode. The function of the Output CFs is to drive the capacitance of the horizontal deflection plates and the associated wiring. To assure a sufficient flow of current at fast time bases, the pentode V398 is used to supply current to the Output CF which drives the negative-going, or left-hand deflection plate. A pentode is chosen as a current booster, since its plate characteristic provides a flat-topped pulse of current. The pulse to drive the grid of the pentode is derived form the waveform at the right-hand deflection plate. This waveform is differentiated by the V390, R390 network before being applied to the grid. Its amplitude is thus proportional to the time base. For the fastest time bases, the tube current is several times normal, but at reduced duty cycle of the time base, well within the dissipation rating of the tubes.

Bootstrap capacitors C364 and C384 are used to help supply the necessary charging current for fast time bases. During calibration these two capacitors are adjusted on the fastest time base for optimum linearity.

EXTERNAL HORIZONTAL AMPLIFIER

When the HORIZONTAL DISPLAY switch, SW348, is in either the EXT. HORIZ. ATTEN X1 or X10 positions, the HORIZ INPUT connector connects to an auxiliary amplifier which uses the tubes and circuits of phase inverters.

External sweep signals are applied to the grid of V303A directly or through a X10 attenuator for the circuit in-phase amplification.

The signal applied to V303A grid is cathode coupled to V314A, which with V314B, is a cathode-coupled, grounded-grid amplifier. Gain of this amplifier can be adjusted by varying R314, EXTERNAL HORIZ. ATTEN., which determines the amount of cathode coupling. The two cathodes must be at the same dc voltage, or variation of R314 will change the dc level. R307, labeled Ext. Horiz. DC Bal on the chassis, can be adjusted so that the cathodes of V314A and V314B are at the same voltage.

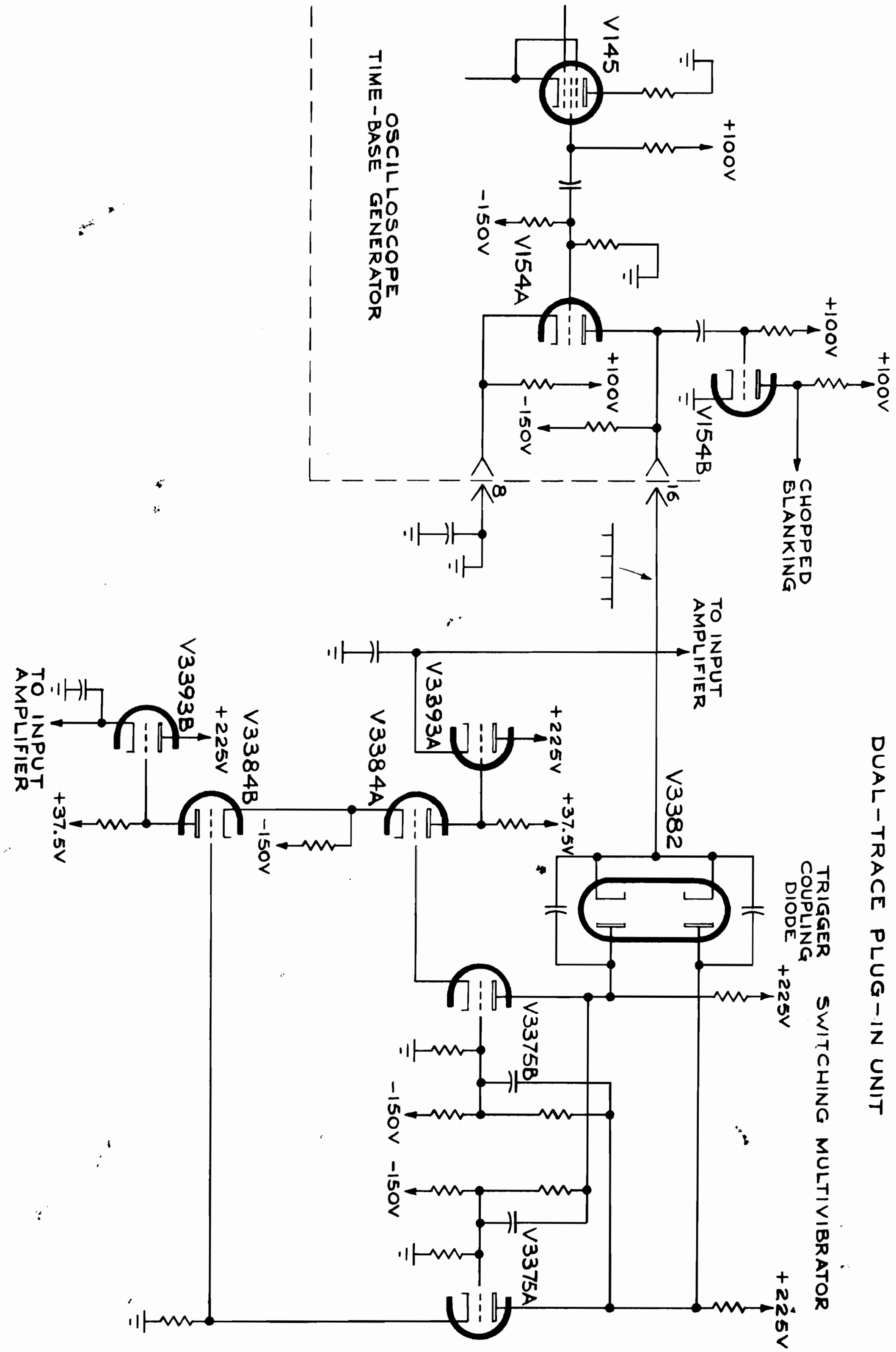


Fig. 4-5. Simplified Dual-Trace Operation.

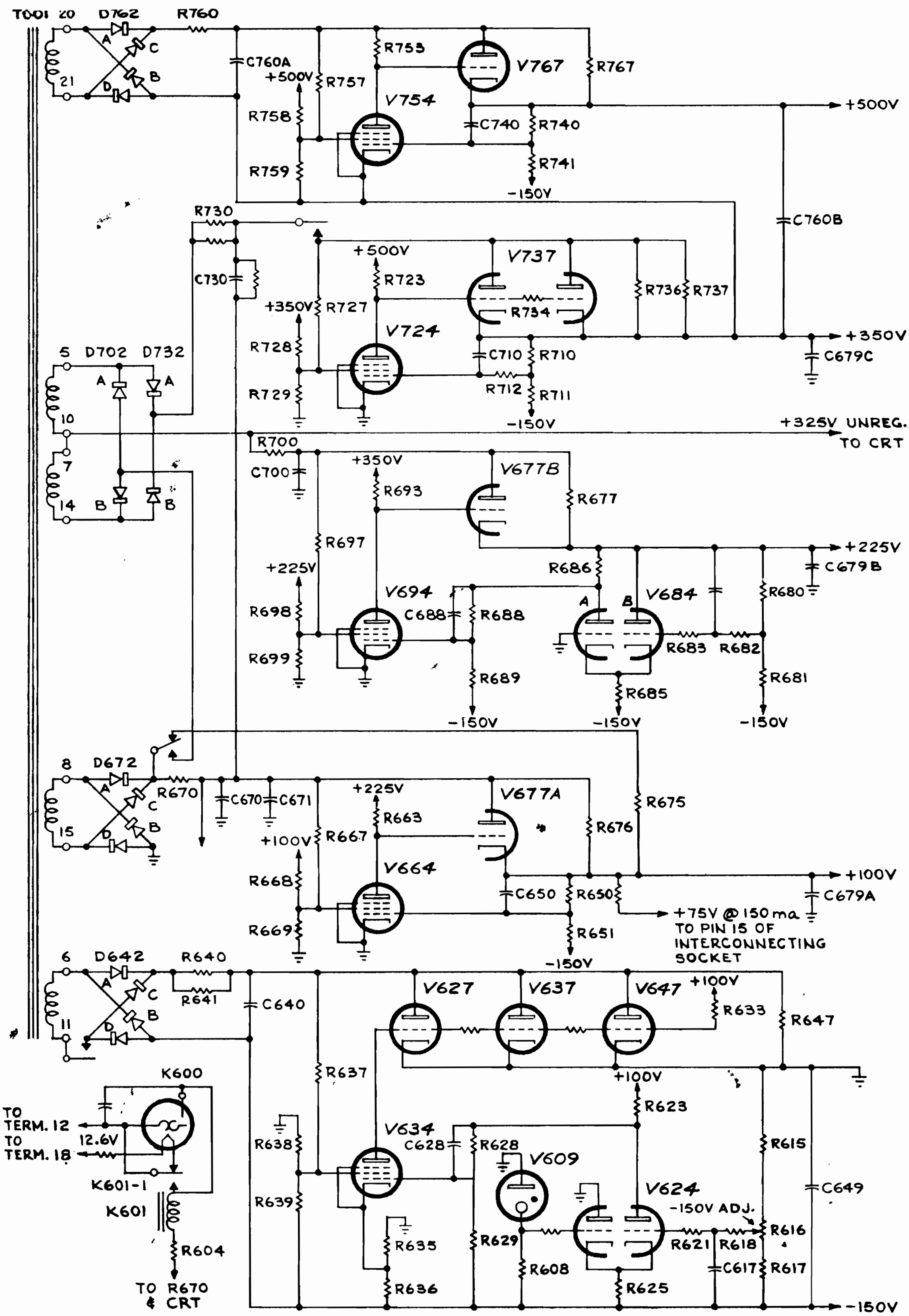


Fig. 4-6. Simplified Type 531A Low-Voltage Power Supply.

Plate output V314B is connected to the Input CF V343A in the Horizontal Sweep Amplifier when the HORIZONTAL DISPLAY switch is in either the EXT. HORIZ. ATTEN X1 or X10 positions.

Note that the external sweep signal must not have a dc component of its own or the dc balance will be upset, and adjustment of the 10-1 gain control will position the trace horizontally.

LOW-VOLTAGE POWER SUPPLY

Power Transformer

Plate and filament power for the tubes in the Type 531A is furnished by a single power transformer, T601. The primary has two equal windings which may be connected in parallel for 117-volt operation, or in series for 234-volt operation. The power supply will maintain regulation over line voltage ranges of 105 to 125 volts, or 210 to 250 volts, rms, 50-60 cycles. Bridge rectifiers are employed for the five separate, full-wave power supplies. The five supplies furnish regulated output voltages of —150, +100, +225, +350 and +500 volts.

—150-Volt Supply

Reference voltage for the —150-volt supply is furnished by a gas diode voltage-reference tube V609. This tube, which has a constant voltage drop, establishes a fixed petential of about —87 volts at the grid of V624A, one-half of a difference amplifier. The grid voltage for the other half of the difference amplifier, V624, is obtained from a divider consisting of R616, R617 and R615. The —150 ADJ. control R616 determines the precentage of total voltage that appears at the grid of V624B and thus determines the total voltage across the divider. This control is adjusted so that the output voltage is exactly —150 volts.

If line-voltage or load fluctuations tend to change the output voltage, an error signal exists between the two grids of the difference amplifier. The error signal is amplified in V624B and V634 and applied to the grids of the series tubes V627, V637 and V647. The resulting changes in voltage at the plates of the series tubes, which will be in a direction to compensate for any change in output voltage, is coupled through the rectifiers to the output to keep this voltage constant. Capacitors C617 and C628 improve the ac gain of the feedback loop to increase the response of the regulator circuit to sudden changes in output voltage.

A small amount of unregulated bus ripple is coupled to the screen of V634 through R637. The phase of the amplified ripple voltage at the plate of V634 is such as to cancel most of the ripple on the —150-volt bus.

+100-Volt Supply

The +100-volt supply is regulated by comparing to ground (the cathode of V664) the voltage of a point near ground potential obtained from the divider R650-R651 connected between the +100-volt bus and the regulated —150-volt supply. Any error voltage that exists is amplified and inverted in polarity by V664 and coupled through the cathode follower V677A to the output to prevent the output voltage from changing. Capacitor C650 improves the ac gain of this circuit.

A small sample of the unregulated bus ripple appears at the screen of V664 through R668. This produces a ripple component at the grid of the cathode follower V677A that is opposite in polarity to the ripple at the plate; this tends to cancel the ripple at the cathode and hence on the +100-volt bus.

This same circuit also improves the regulation in the presence of line-voltage variations.

+225-Volt Supply

Rectified voltage from terminals 10 and 14 of the power transformer is added to the voltage supplying the +100-volt regulator to furnish power for the +225-volt regulator. This supply is regulated by comparing to ground (the grid of V684A) the voltage of a point near ground obtained from the divider R680-R681 connected between the +225-volt bus and the regulated —150-volt supply. Any error voltage that exists between the grids of the difference amplifier (V684) is amplified in both V684 and V694, and coupled through the cathode follower V677B to the +225-volt bus. The change in voltage at the cathode of V677B, due to the regulator action, will be opposite in polarity to the original error signal and will thus tend to keep the output constant. This supply also furnishes an unregulated output of about +325 volts for the oscillator in the crt high-voltage supply. It is unnecessary to regulate this voltage as the crt supply has its own regulator circuits.

+350-Volt Supply

Rectified voltage from terminals 5 and 14 of T601 is added to voltage supplying the +100-volt regulator to furnish power for the +500-volt regulator. This supply is regulated by comparing to ground the voltage of a point near ground obtained from the divider R710-R711 connected between the +350-volt bus and the regulated —150-volt supply. The operation of the regulated circuit is the same as that described for the +100-volt supply.

+500-volt Supply

Rectified voltage from terminals 20 and 21 of T601 is added to the regulated side of the +350-volt supply to furnish power for the +350-volt regulator. This supply is regulated by comparing to the regulated +350 volts the voltage of a point near +350 obtained from the divider R740-R741 connected between the +500-volt bus and the regulated —150 volt supply. The regulator action of this circuit is the same as that described for the +100-volt supply.

Time Delay

A Time-Delay relay delays the application of dc voltages to the amplifier tubes in the instrument for about 25 seconds.

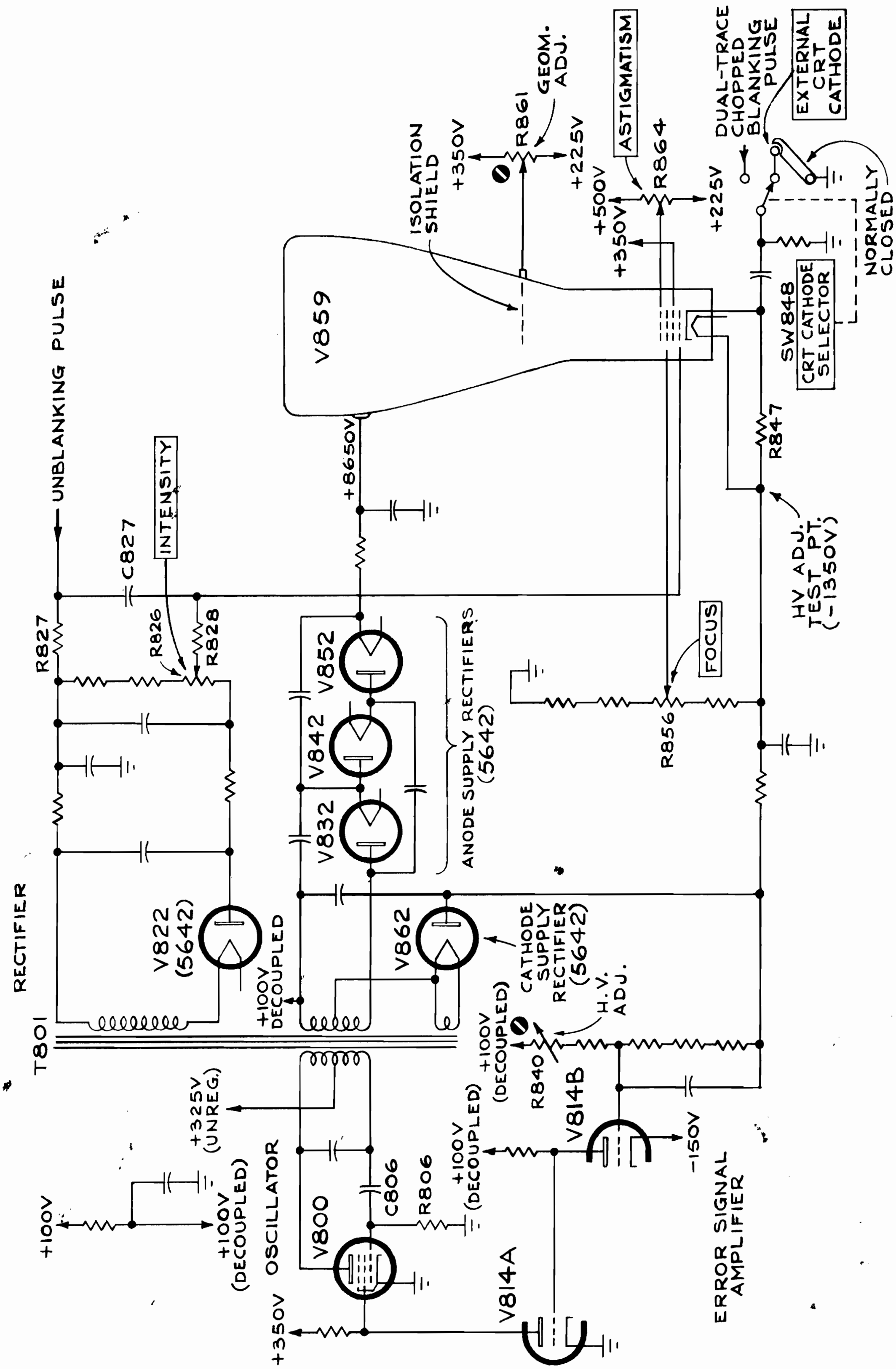


Fig. 4-7. Simplified Type 531A CRT Circuit.

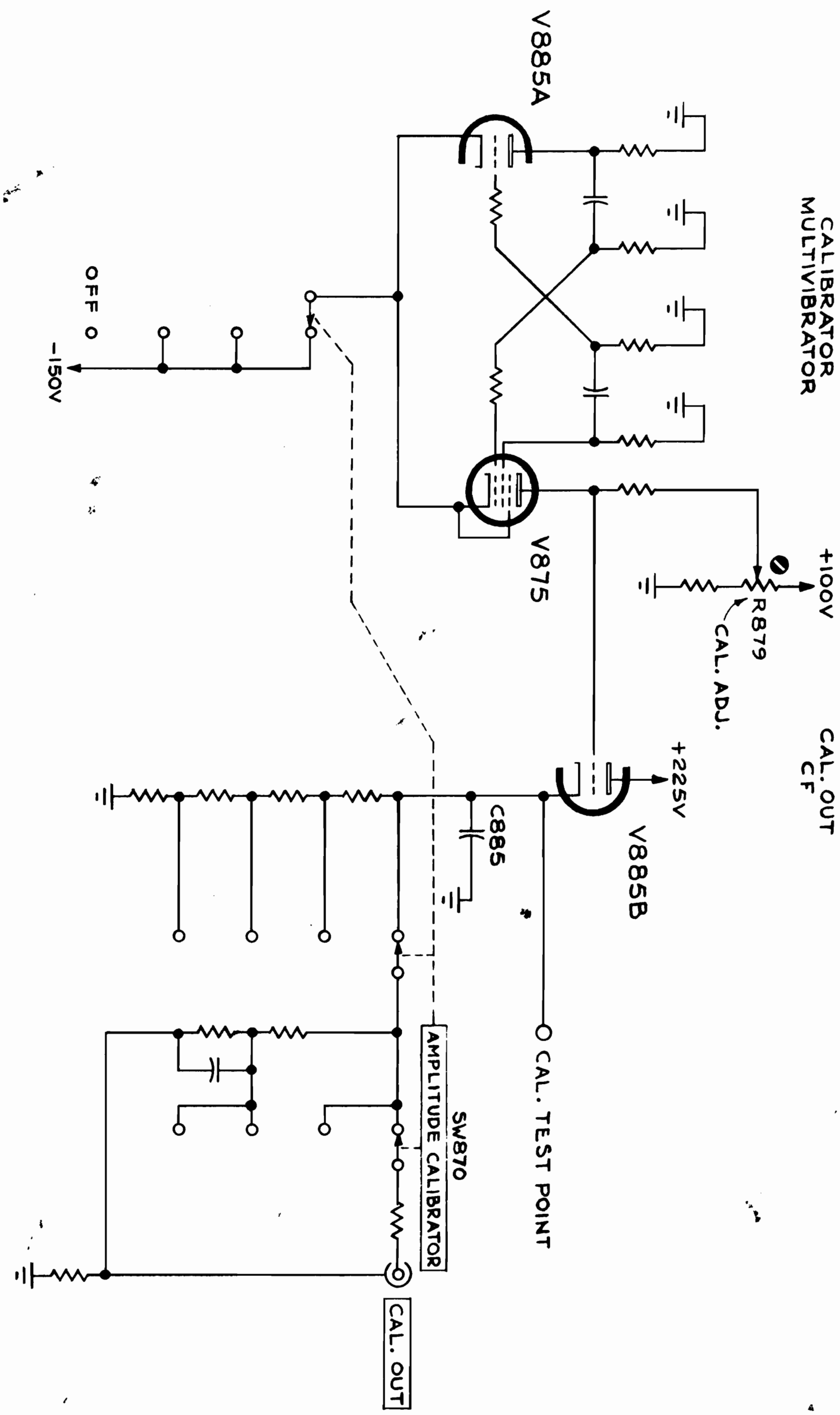


Fig. 4-8. Simplified Type 531A Calibrator.

This delay is to allow the tube heaters time to bring the cathodes up to emission temperature before operating potentials are applied.

CRT CIRCUIT

Cathode-Ray Tube Control Circuits

The INTENSITY control R826 varies the voltage at the grid of the crt to control the beam current. The FOCUS control R856 varies the voltage at the focusing ring to focus the trace. The ASTIGMATISM control R864 varies the voltage at the astigmatism anode to focus the spot in both dimensions simultaneously. The GEOM. ADJ. R861 varies the field the beam encounters as it emerges from the deflection system to control the linearity at the extremes of deflection.

The CRT CATHODE SELECTOR switch SW848 connects the cathode of the crt through C848 to either a rear panel binding post labeled EXTERNAL CRT CATHODE or to the plate of V154B in the Time-Base Generator circuit. When in the DUAL-TRACE CHOPPED BLANKING position, the cathode of the crt is connected to receive positive pulses from the Time-Base Generator circuit to blank the crt during switching while operating a dual-trace plug-in unit in the chopped mode.

When SW848 is in the EXTERNAL CRT CATHODE position, the cathode circuit of the crt is connected to the binding post mentioned previously. A bare bus bar normally connects the binding post to ground. When intensity modulation of the beam is desired, the bus bar can be removed so that the modulating signal can be coupled to the crt cathode.

High-Voltage Supply

A single 60-kc Hartley oscillator furnishes power for the three power supplies that provide accelerating potentials for the crt. The main components in the Oscillator circuits are the pentode V800 and primary of T801 turned by C808.

A half-wave rectifier V862 provides —1350 volts for the crt cathode. A half-wave voltage tripler circuit, V832, V842 and V852, provides —8650 volts for the post-anode accelerator. This provides a total accelerating voltage of 10,000 volts. Both supplies are tied to the +100-volt regulated supply through the decoupling filter R801-C801.

A floating half-wave rectifier V822 furnishes bias voltage (about —1450 volts) for the crt grid. This floating grid supply, independent of the cathode supply, is required in order to provide dc coupled unblanking to the crt grid. All three supplies employ capacitor-input filters.

The —1350-volt cathode supply is regulated by comparing to the —150-volt regulated supply (the cathode of V814B) a voltage near —150 volts obtained from a tap on the divider connected between the decoupled +100-volt bus and the —1350-volt bus. The total resistance of the divider, and hence the voltage across the divider, is determined by the setting of R840 labeled HV ADJ. When this control is properly adjusted, the voltage at the HV ADJ. TEST POINT will be exactly —1350 volts.

If variations in loading should tend to change the voltage on the —1350-volt bus, an error signal will exist between the grid and cathode of V814B. The error signal will be amplified by V814B V814A; the output of V814A varies the screen voltage of oscillator tube V800, thereby controlling its output.

The +8650-volt supply and the negative bias supply are regulated indirectly as the output voltage of all three supplies is proportional to the output of the Oscillator circuit.

Unblanking

As mentioned previously, dc-coupled unblanking is accomplished by employing separate power supplies for the grid and cathode of the crt. The unblanking pulses from the Time-Base Generator are transmitted to the crt grid through the cathode follower V183B and the floating grid supply.

At the faster sweep rates the stray capacitance in the circuit makes it difficult to pull up the floating supply fast enough to unblank the crt in the required time. To overcome this, an isolation network composed of C827, C828, C829, R827 and R829 is employed. By this arrangement the fast leading edge of the unblanking pulse is coupled through C827 to the grid of the crt. For short-duration unblanking pulses, at the faster sweep rates, the power supply itself is not appreciably moved.

The longer unblanking pulses, at the slower sweep rates, charge the stray capacitance in the circuit through R827. This pulls up the floating supply and holds the grid at unblanked potential for the duration of the blanking pulse.

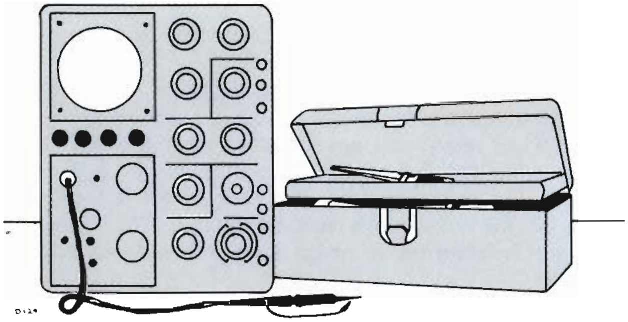
Calibrator

The Calibrator is a square-wave generator producing an output at approximately 1 kc which is available at the front panel CAL. OUT connector. It consists of V875 and V885A comprising a multivibrator, connected so as to switch the cathode follower V885B between two operating stages, cutoff and conduction.

During the negative portion of the multivibrator waveform the grid of V885B is driven well below cutoff and its cathode rests at ground potential. During the positive portion of the waveform V875 is cut off and its plate rests slightly below +100 volts. The voltage at the grid of V885B when this tube is cut off, is determined by the setting of the CAL. ADJ. control R879 part of the divider connected between +100 volts and ground.

Cathode-follower V885B has a precision, tapped divider for its cathode resistor. When the CAL. ADJ. control is properly adjusted, the cathode of V885B is at +100 volts when V875 is cut off. By means of the tapped divider R885 through R893 and a second 1000 to 1 divider R896-R897, output voltages from 0.2 millivolt to 100 volts in steps are available. C885, connected between the cathode of V885B and ground, corrects the output waveform for a slight overshoot.

NOTES



SECTION 5

MAINTENANCE

PREVENTIVE MAINTENANCE

Air Filter

Care must be taken to assure free ventilation of the Type 531A inasmuch as some of the components are operated at dissipation levels such that excessive interior temperatures will result without adequate air circulation. To assure free passage of air the instrument must be placed so that the intake is not blocked and the filter must be kept clean. Moreover, the side panels and bottom cover must be in place for proper air circulation. Do not remove the covers except during maintenance.

A washable EZ KLEEN filter is used at the air intake part of the instrument. Under normal operating conditions the filter should be inspected and cleaned if necessary every three to four months. More frequent inspection is required when the operating conditions are more severe.

The following cleaning instructions are issued by the filter manufacturer:

(1) If grease or dirt load is light, remove filter from installation and rap gently on hard surface to remove loose dirt. Flush remaining dirt or grease out of filter with a stream of hot water or steam.

(2) If load is too heavy for treatment described in (1), prepare mild soap or detergent solution in pan or sink deep enough to cover filter when laid flat. Agitate filter up and down in solution until grease or dirt is loosened and floated off.

(3) Rinse filter and let dry.

(4) Dip or spray filter with fresh Filter Coat or Handi-Coater. These products are available from the local representative of the Research Products Corporation and from most air conditioner suppliers.

Fan Motor

The fan motor bearings should be lubricated every three or four months with a few drops of light machine oil (see Fig. 5-1). Failure to lubricate the bearings periodically will cause the fan to slow down or stop thereby causing the instrument to overheat. If your oscilloscope is equipped with a dc fan motor—modification number 101—and if it operates throughout the working day, we suggest that you oil the bearings lightly once a month.

You should check the condition of the brushes of dc fans every other month since their life expectancy is approximately 6 months under conditions of daily use.

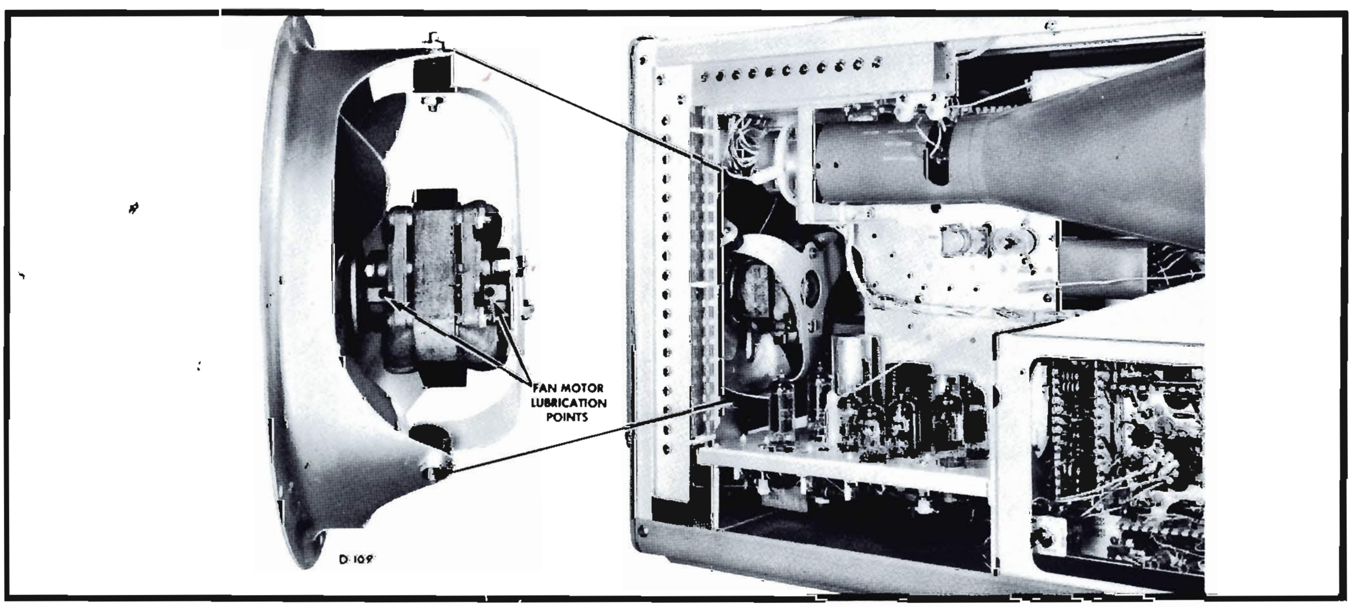


Fig. 5-1. Location of the fan motor lubrication points.

Recalibration

The Type 531A is a stable instrument and will provide many hours of trouble-free operation. To insure the reliability of measurements obtained on the Type 531A, we suggest that its calibration be checked after each 500 hours of operation, or at least every six months if used intermittently. A check of the calibration also provides a means for checking the operation of each circuit. Minor operational deficiencies that are not apparent in normal use are often detected during a calibration check.

Visual Inspection

You should visually inspect the entire oscilloscope every few months for possible circuit defects. These defects may include such things as loose or broken connections, damaged binding posts, improperly seated tubes, scorched wires or resistors, missing tube shields, or broken terminal strips. For most visual troubles the remedy is apparent; however, particular care must be taken when heat-damaged components are detected. Overheating of parts is often the result of other, less apparent, defects in the circuit. It is essential that you determine the cause of overheating before replacing heat-damaged parts in order to prevent further damage.

Soldering and Ceramic Strips

Many of the components in your Tektronix instruments are mounted on ceramic terminal strips. The notches in these strips are lined with a silver alloy. Repeated use of excessive heat, or use of ordinary tin-lead solder will break down the silver-to-ceramic bond. Occasional use of tin-lead solder will not break the bond if excessive heat is not applied.

If you are responsible for the maintenance of a large number of Tektronix instruments, or if you contemplate frequent parts change, we recommend that you keep on hand a stock of solder containing about 3% silver. This type of solder is used frequently in printed circuitry and should be readily available from radio-supply houses. If you prefer, you can order the solder directly from Tektronix in one pound rolls. Order by Tektronix part number 251-514.

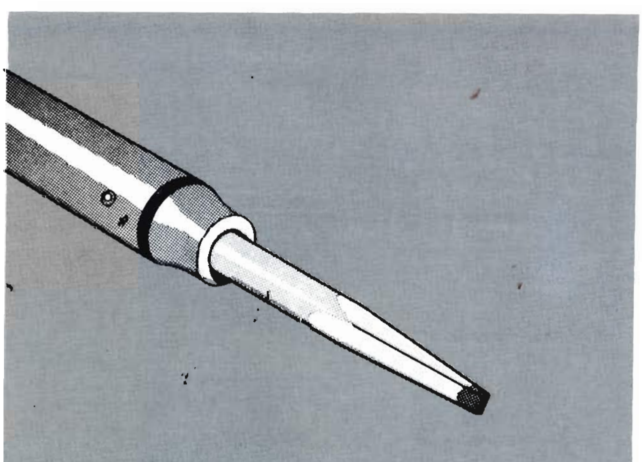


Fig. 5-2. Soldering iron tip properly shaped and tinned.

Because of the shape of the terminals on the ceramic strips it is advisable to use a wedge-shaped tip on your soldering iron when you are installing or removing parts from the strips. Fig. 5-2 will show you the correct shape for the tip of the soldering iron. Be sure to file smooth all surfaces of the iron which will be tinned. This prevents solder from building up on rough spots where it will quickly oxidize.

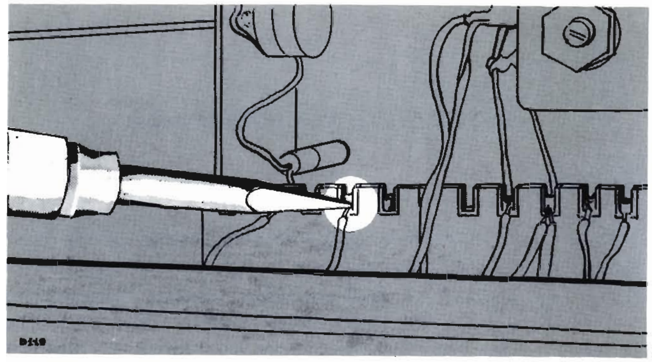


Fig. 5-3. Correct method of applying heat in soldering to a ceramic strip.

When removing or replacing components mounted on the ceramic strips you will find that satisfactory results are obtained if you proceed in the manner outlined below.

1. Use a soldering iron of about 75-watt rating.
2. Prepare the tip of the iron as shown in Fig. 5-2.
3. Tin only the first 1/16 to 1/8 inch of the tip. For soldering to ceramic terminal strips tin the iron with solder containing about 3% silver.
4. Apply one corner of the tip to notch where you wish to solder (see Fig. 5-3).
5. Apply only enough heat to make the solder flow freely.
6. Do not attempt to fill the notch on the strip with solder; instead, apply only enough solder to cover the wires adequately, and to form a slight fillet on the wire as shown in Fig. 5-4.

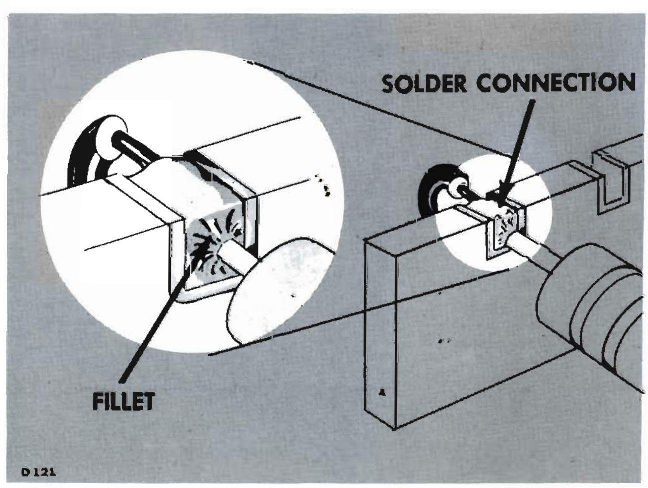


Fig. 5-4. A slight fillet of solder is formed around the wire when heat is applied correctly.

In soldering to metal terminals (for example, pins on a tube socket) a slightly different technique should be employed. Prepare the iron as outlined above, but tin with ordinary tin-lead solder. Apply the iron to the part to be soldered as shown in Fig. 5-5. Use only enough heat to allow the solder to flow freely along the wire so that a slight fillet will be formed as shown in Fig. 5-5.

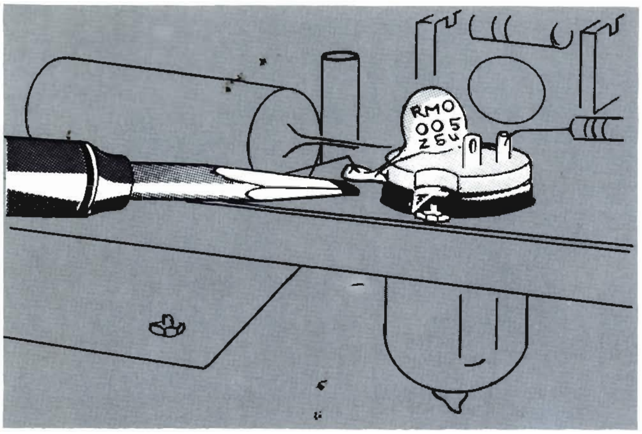


Fig. 5-5. Soldering to a terminal. Note the slight fillet of solder—exaggerated for clarity—formed around the wire.

General Soldering Consideration

When replacing wires in terminal slots clip the ends neatly as close to the solder joint as possible. In clipping the ends of wires take care the end removed does not fly across the room as it is clipped.

Occasionally you will wish to hold a bare wire in place as it is being soldered. A handy device for this purpose is a short length of wooden dowel, with one end shaped as shown in Fig. 5-6. In soldering to terminal pins mounted in plastic rods it is necessary to use some form of "heat sink" to avoid melting the plastic. A pair of long-nosed pliers (see Fig. 5-7) makes a convenient tool for this purpose.

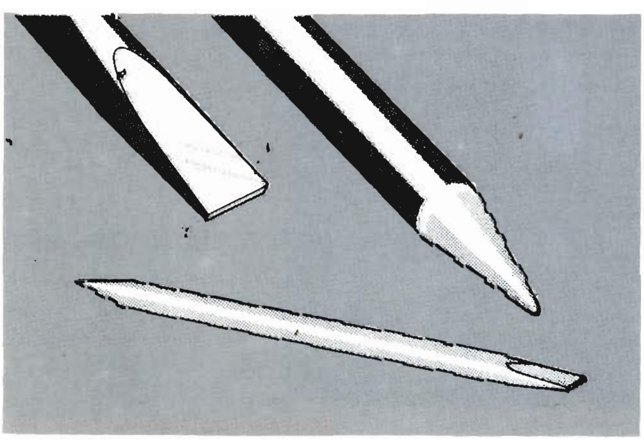


Fig. 5-6. A soldering aid constructed from a ¼ inch wooden dowel.

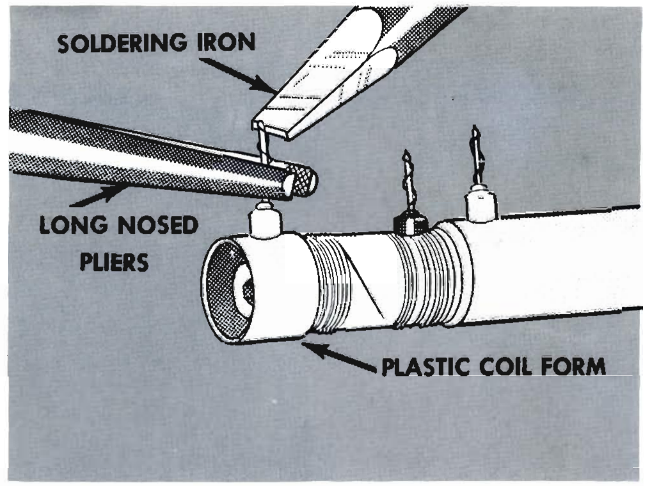


Fig. 5-7. Soldering to a terminal mounting in plastic. Note the use of the long-nosed pilers between the iron and the coil form to absorb the heat.

Ceramic Strips

Two distinct types of ceramic strips have been used in Tektronix instruments. The earlier type mounted on the chassis by means of #2-56 bolts and nuts. The later type is mounted with snap-in, plastic fittings. Both styles are shown in Fig. 5-8.

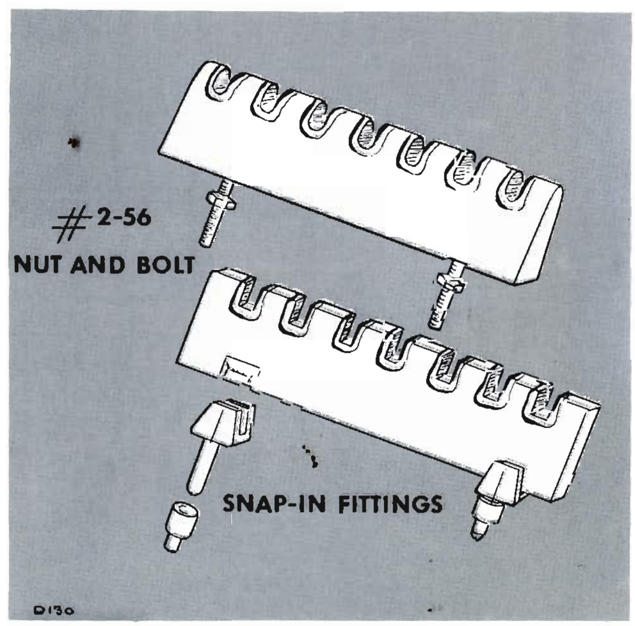
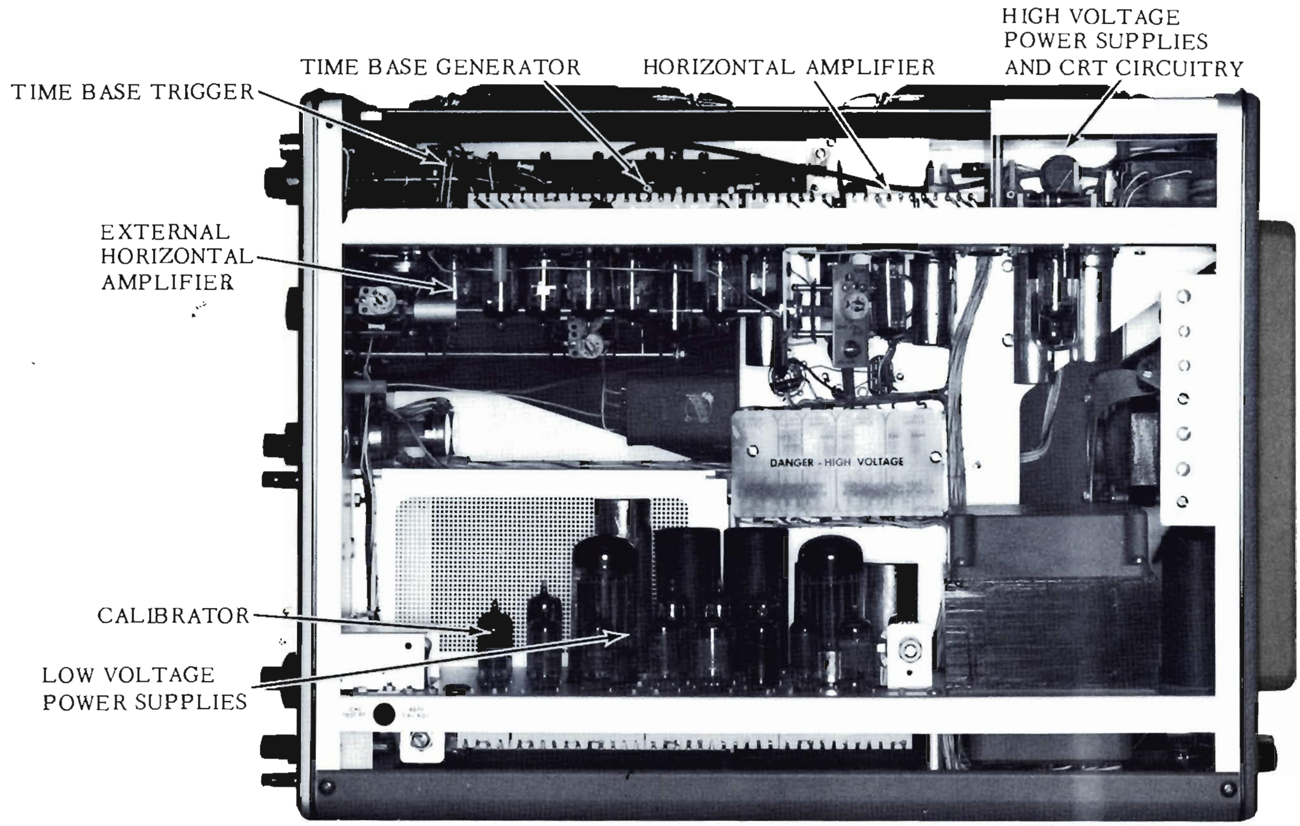


Fig. 5-8. Two types of ceramic strip mountings.

To replace ceramic strips which bolt to the chassis, screw a #2-56 nut onto each mounting bolt, positioning the bolt so that the distance between the bottom of the bolt and the bottom of the ceramic strip equals the height at which



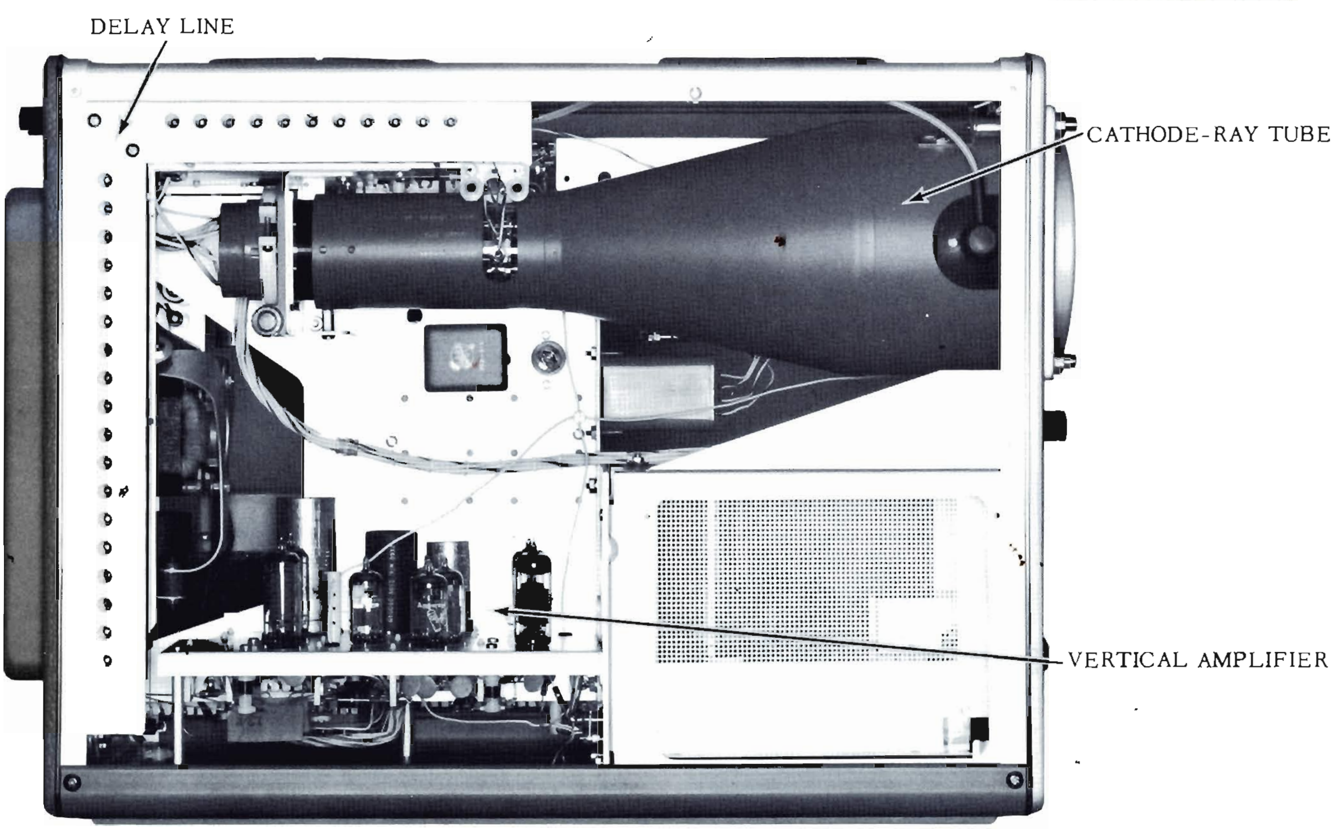


Fig. 5-9. Physical location of the circuits which compose the Type 531A Oscilloscope.

you wish to mount the strip above the chassis. Secure the nuts to the bolts with a drop of red glyptal. Insert the bolts through the holes in the chassis where the original strip was mounted, placing a #2 star washer between each nut and the chassis. Place a second set of #2 flat washers on the protruding ends of the bolts, and fasten them firmly with another set of #2-56 nuts. Place a drop of red glyptal over each of the second set of nuts after fastening.

Mounting Later Ceramic Strips

To replace strips which mount with snap-in plastic fittings, first remove the original fittings from the chassis. Assemble the mounting post on the ceramic strips. Insert the nylon collar into the mounting holes in the chassis Carefully force the mounting post into the nylon collars. Snip off the portion of the mounting post which protrudes below the nylon collar on the reverse side of the chassis.

NOTE

Considerable force may be necessary to push the mounting rods into the nylon collars. Be sure that you apply this force to that area of the ceramic strip above the mounting rods.

TROUBLESHOOTING PROCEDURE

This section of the manual contains information for troubleshooting your oscilloscope. Before attempting to troubleshoot the instrument, however, make sure that any apparent trouble is actually due to a malfunction within the instrument and not to improper control settings or to a faulty plug-in unit. Instructions for the operation of the oscilloscope and general information concerning plug-in operation, are contained in the Operating Instructions section of this manual. Operating instructions for a specific plug-in unit will be found in the manual for that unit.

To determine that the oscilloscope is at fault, the plug-in unit may be replaced with another known to be in good operating condition. If the trouble is still apparent, it is almost a certainty that the oscilloscope is at fault. However, should the trouble appear to have been corrected by replacing the plug-in unit, the trouble most likely lies within the original plug-in unit and not with the oscilloscope.

Tube failure is the most prevalent cause of circuit failure. For this reason, the first step in troubleshooting any circuit in the instrument is to check for defective tubes, preferably by direct substitution. Do not depend on tube testers to adequately indicate the suitability of a tube for certain positions within the instrument. The criterion for usability of a tube is whether or not it works satisfactorily in the instrument. Be sure to return all good tubes to their sockets; if this procedure is followed less recalibration of the instrument will be required upon completion of the servicing.

When replacing any tube in the instrument, check first to see that components through which the tube draws current have not been damaged. Shorted tubes will sometimes overload and damage plate-load and cathode resistors. These damaged components can generally be located by a visual inspection of the wiring. If no damaged components are apparent, and if tube replacement does not restore operation, it will be necessary to make measurements or other checks within the circuit to locate the trouble.

The component number of each resistor, inductor, capacitor, vacuum tube, control and switch is shown is on the circuit diagrams. The following chart lists the component numbers associated with each circuit:

All numbers less than 100	Time-Base Trigger
100 series	Time-Base Generator
300 series	Horizontal Amplifier
500 series	Vertical Amplifier
600 series and 700 series	Low-Voltage Power Supply
800 series	CRT Circuits, High Voltage and Square-Wave Calibrator
900 series	Delay Line

Switch wafers shown on the schematic diagrams are coded to indicate the position of the wafer on the actual switches. The number position of the code refers to the wafer number on the switch assembly. Wafers are numbered from the front of the switch to the rear. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function. Photographic details of these switches are shown on the same fold-out page as the corresponding schematic diagram. These photographs are provided as parts location guides.

CIRCUIT TROUBLESHOOTING

Although the Type 531A is a complex instrument, it can be thought of as consisting of six main circuits, in addition to the Calibrator circuit. These are the:

1. Low-Voltage Power Supply.
2. CRT Circuit and High-Voltage Power Supply.
3. Vertical Amplifier and Delay Line.
4. Time-Base Trigger Circuit.
5. Time-Base Generator.
6. Horizontal Amplifier.

The first circuit to check, for practically any type of trouble, is the Low-Voltage Power Supply. Because of the circuit configuration employed, it is possible for an improper power supply voltage to affect one circuit more than the others. For example, if the gain of the Vertical Amplifier should decrease slightly, while the other circuits appear to be functioning normally, this could be due to an improper supply voltage and not to any condition originating in the Vertical Amplifier. In cases of this type, valuable time can be saved by checking the power supply first.

On the other hand, the crt display can often be used to isolate trouble to one particular circuit when trouble obviously exists in that circuit. If there is no vertical deflecton, for example, when the intensity and horizontal deflection appear to be normal, it is apparent that an open condition exists in the Vertical Amplifier and this circuit should be investigated first.

Front-Panel Checks

The following front-panel checks will help you to isolate the trouble in an instrument to a given circuit. The inter-relation between circuits is such that these checks are not always completely accurate in isolating a trouble to a given circuit. If you are unfamiliar with the instrument these front-panel checks may prove helpful in starting to look for the trouble.

Before attempting any of the following front-panel checks make sure that the plug-in installed in the instrument is operating correctly. If the pilot lamp fails to light when the POWER switch is turned to the ON position, and if the fan fails to operate, turn to the section on troubleshooting the Low-Voltage Power Supply. If the pilot light and fan both operate but the Time-Delay Relay fails to operate with an audible "click" after one minute you should also consult the section on Troubleshooting the Low-Voltage Power Supply.

With an operating plug-in installed, and the pilot light and fan both operating, allow the oscilloscope to run for several minutes.

Set the front-panel controls as follows:

STABILITY	full right (clockwise)
TRIGGERING LEVEL	0
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
VARIABLE (TIME/CM)	full right
TIME/CM	5 MILLISEC
HORIZONTAL DISPLAY	NORMAL
FOCUS	mid-scale
INTENSITY	full-left (counterclockwise)
ASTIGMATISM	mid-scale
SCALE ILLUMINATION	mid-scale
HORIZONTAL POSITION	mid-scale
VERNIER	mid-scale

The settings of other controls are not critical at this time.

If you are using a Type TU-1 or TU-2 Test-Load Plug-In Unit set the toggle switch to the 1:1 position and the CALIBRATOR switch to the .2 VOLTS position. If using another type of plug-in set the VOLTS/CM switch to 1 volt and the AMPLITUDE CALIBRATOR switch to 2 VOLTS.

Using a patch cord which introduces no attenuation connect the CAL. OUT connector to the INPUT connector of the plug-in preamplifier. Advance the INTENSITY control to the mid-scale position.

Now examine the face of the crt. If no display is evident examine the Beam-Position Indicator lamps. If the display is positioned off the screen vertically turn the VERTICAL POSITION control from one extreme position to the other, watching the face of the crt as you do so. If no display appears, and operation of the VERTICAL POSITION control has no effect on the Beam-Position Indicator lamps turn to the section on Troubleshooting the Vertical Amplifier.

If the display which appears consists of a horizontal line, you may check the operation of the calibrator by removing the end of the patch cord which is inserted into the CAL. OUT connector and holding it in your hand. A series of sloping vertical lines appearing on the crt indicate that the Vertical Amplifier is operating and that the Amplitude Calibrator is probably inoperative. See the section on Troubleshooting the Amplitude Calibrator for the remedy.

If the operation of the VERTICAL POSITION control causes the vertical Beam-Position Indicator lamps to indicate the display as centered, rotate the HORIZONTAL POSITION control from one extreme position to the other. If the horizontal Beam-Position Indicator lamps still indicate the display is off the screen refer to the section on Troubleshooting the Horizontal Amplifier.

If both sets of Beam-Position lamps indicate that the display is centered, but no display is observed, CAUTIOUSLY advance the INTENSITY control. Watch for a display to appear on the screen. If no display is seen or if the display is of low intensity but otherwise normal, refer to the section on Troubleshooting the CRT Circuit.

TROUBLESHOOTING THE VERTICAL AMPLIFIER

No Spot or Trace on CRT

If all power supply voltages are normal, and the crt is known to be good, failure to display a spot or trace on the screen will be due to improper positioning voltages. This condition is caused by dc unbalance in either or both of the deflection amplifier circuits.

To determine which circuit is at fault, adjust the Time-Base controls for a free-running sweep at 1 millisec/cm (STABILITY control full right). Set the INTENSITY control to midscale. Using a screwdiver with an insulated handle, short the Vertical defection plates together at the neck pins on the crt. These are the pins marked BLUE (UPPER) and Brown (LOWER). Be careful not to short either pin to the metal shield around the crt, or to the pin marked ORANGE (GEOM). If dc unbalance is being produced in the vertical deflection circuit, the trace will appear at or near the center of the crt. If the trace does not appear, the trouble does not lie in the vertical circuit. The dc balance of the horizontal circuit can be checked in a similar manner, by shorting the horizontal deflection plates together.

If it is determined that the vertical deflection circuit is unbalanced, the next step is to check the Delay Line. For this check, it is convenient to have a short lead (about 6 to 10 inches) with a rubber-covered alligator clip on each end. Connect this lead across the input to the Delay Line. If the trace appears on the crt, the Delay Line is not at fault. If the trace does not appear, check for an open line by turning off the oscilloscope and checking the continuity of both sides of the line with an ohmmeter.

If the Delay Line is not at fault, connect the shorting strap between the grids (pin 2) of the output amplifiers, V554 and V564. If the trace does not appear, check for an open plate inductor (L553 or L563).

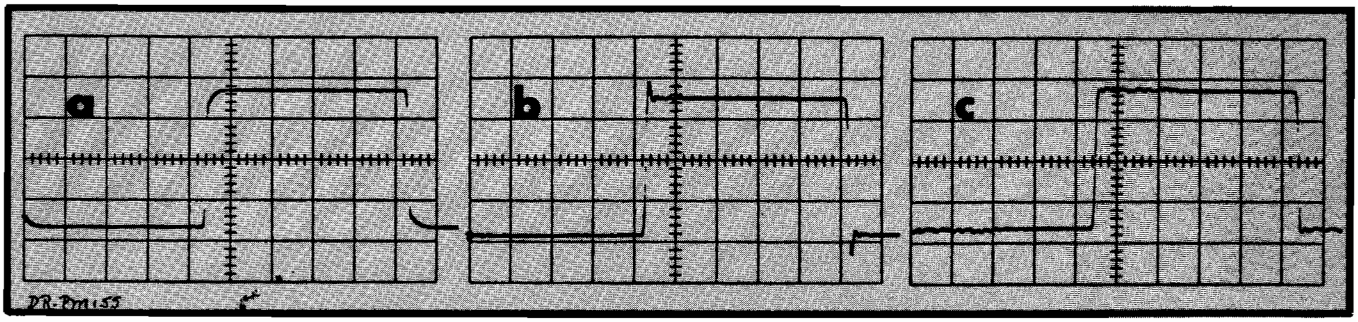


Fig. 5-10. Three types of high-frequency distortion.

If the trace does appear when the grids of the Output Amplifiers are shorted together, the trouble is occurring in one of the input stages. If tube replacement does not correct the trouble, then look for open peaking coils, defective resistors, and shorted or leaky capacitors.

Insufficient or No Vertical Deflection

Insufficient deflection indicates a change in the gain characteristics of the Vertical Amplifier. If only a slight change in deflection is apparent, the circuit can normally be recalibrated for gain. In this event, refer to the Calibration Procedure section of this manual.

If the change in deflection is more pronounced, or if there is no deflection at all the tubes should first be checked Then check for components which affect the gain of the circuit but not the dc balance. Such components would be the common plate-load resistors R505 and R528, the common cathode resistors R513, R514, R558, R568, and the GAIN ADJ. control R570.

Waveform Distortion

Any waveform distortion that may be produced by the Type 531A will generally be of high-frequency nature. There will be no low-frequency distortion since the deflection circuit is dc-coupled from input to output (unless one or more of the tubes enter into heavy grid current, a condition that will produce other types of distortion as well).

A distortion-free positive step function, having a rise-time of 10 nanoseconds or less, may be used to observe the high-frequency characteristics of the oscilloscope/plug-in combination. This is illustrated in the photographs of Fig. 5-10.

Insufficient high-frequency peaking, which limits the rise time and consequently the band-width, will produce the "rolloff" or undershoot condition illustrated in Fig. 5-10a. "Rolloff" is the result of insufficient high-frequency compensation. A small amount of rolloff is normally due to a change, with age, in the characteristics of the circuit components, and can usually be compensated by adjusting

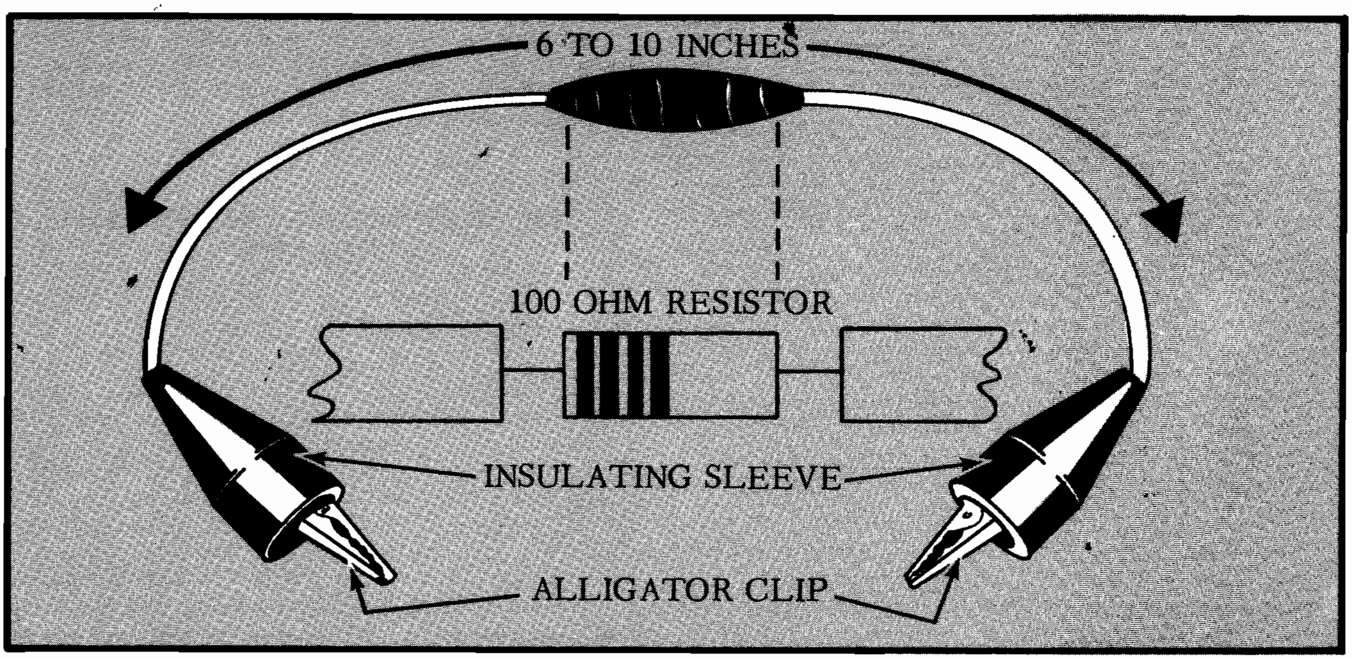


Fig. 5-11. Shorting strap useful in locating an unbalanced stage in a vertical or horizontal amplifier.

the variable peaking coils. If the rolloff is more pronounced the tubes should be checked. If a tube cannot deliver current, instantaneously on demand, the transients in the signal will not be produced.

Shorted or partially shorted peaking coils will result in a rolloff. Be especially careful when soldering around the peaking circuits as hot solder dropping on a coil may burn through the insulation and short the turns.

Excessive high-frequency peaking will produce the "overshoot" condition illustrated in Fig. 5-10b. This is generally caused by misadjusting the peaking coils. In these cases the distortion can generally be eliminated by readjusting the variable peaking coils L506 and L523 for the Input Amplifiers, and L553 and L563 for the Output Amplifiers.

An overshoot at the leading edge of a fast-rise pulse may also be the result of cathode interface in one of the amplifier tubes. Since the time constant of the interface layer is normally in the range from 0.1 to 3 μsec, this effect is most noticeable on waveforms whose period is long compared to the interface time constant. This condition is produced by the tubes themselves, so it is important to first check the tubes when such distortion is evident.

An improperly adjusted Delay Line will produce the "wrinkle" condition illustrated in Fig. 5-10c. These wrinkles are caused by inter-section impedance mismatches. If the Delay Line is badly detuned, the top of the pulse will be uneven instead of smooth and flat. The leading corner may either overshoot or rolloff. If one or two sections of the line are detuned, either due to a shorted coil or defective capacitor, you will notice an aberration in the waveform in the region affected by the defective component. Before adjusting the trimmers in the Delay Line, be sure that all other sources of waveform distortion have been eliminated.

TROUBLESHOOTING THE TIME-BASE

Unstable Triggering

If the sweep generator is not being properly triggered a stable display of a waveform will not be possible. If the sweep can be turned off and on with the STABILITY control (for any setting of the TRIGGERING MODE switch except AUTOMATIC) the sweep generator is capable of being triggered; this indicates the trigger circuitry is not being triggered; this indicates the trigger circuitry is not functioning properly. The first step is to replace the Trigger Pickoff Tube V584 in the Vertical Amplifier. The operation of this stage can also be checked by observing the signal available at the VERT. SIG. OUT binding post with another oscilloscope. If no signal is available at this connector the Trigger Pickoff stage is defective; a proper signal at this connector indicates the stage is functioning correctly.

If the Trigger Pickoff stage is operating correctly, trouble exists in the Time-Base Trigger circuit. To check the quiescent stage of the circuit, set the TRIGGERING MODE switch to AC, the TRIGGER SLOPE switch to —INT. and the TRIGGERING LEVEL control to 0. Next, connect a jumper wire from the junction of R19, R20, and C20 (on the Trigger Switch) to ground. This fixes the voltage at the grid of V24B at ground potential. Then measure the voltage at the plate of V24B; this should be about +85 volts. If this voltage does not measure very close to +85 volts, replace the Trigger Input tube V24. If necessary, check for off-value resistors, broken leads and poor switch contacts.

The next step is to connect the voltmeter between the plate of V24B and the grid of V45B (the junction of R38, R37, C37 and R41 is more convenient than the grid of V45B). The voltage between the plate of V24B and grid of V45A (or the divider side of R41) should not exceed about 2.75 volts. It is the function of the TRIGGERING LEVEL CENTERING control R39 to set the voltage at the grid of V45A. With the grids of V45 at about the same voltage the center of the hysteresis of the Trigger Multivibrator circuit will be at the proper level. It is difficult to measure the voltage directly between the two grids of V45 due to the loading of the voltmeter; for this reason we suggest the voltage be measured between the plate of V24B and the grid circuit of V45B. A voltage of 2.5 to 2.75 volts between these points will indicate proper quiescent operation.

If the voltage at the grid of V45B cannot be adjusted to within 2.5 to 2.75 volts of the voltage at the plate of V24B trouble in the Trigger Multivibrator is indicated. Replace the tube; then, if necessary, check for off-value resistors, broken leads and poor switch connections.

Conversely, if the voltages are found to be correct, the adjustment of the TRIGGER SENSITIVITY control R47 can be checked. Refer to Step (6) in the Calibration Procedure for the proper method of checking the adjustment of this control.

When triggering in the DC mode from the signal being observed (TRIGGER SLOPE at + or—INT.), the INT. TRIG. DC LEVEL ADJ., R3 and its associated components are connected to the input grid of V24. This control is adjusted so that the input grid (pin 7 at —INT; pin 2 at +INT) is at ground potential when the trace is centered vertically on the crt. If the voltage at the input grid cannot be adjusted to zero when the triggering-switch controls are in the indicated positions, this control and its associated components should be checked.

TROUBLESHOOTING THE TIME-BASE GENERATOR

No Horizontal Sweep

If the Time-Base Generator is not producing a sawtooth sweep voltage when the STABILITY control is adjusted for a free-running sweep some defect in the generator is hanging up the Miller circuit. Depending on the on-off characteristics of the diodes V152, the Miller circuit may be hung up at either the high end or the low end of the sawtooth. The manner in which it is hung up may be determined by measuring the voltage at the SAWTOOTH OUT binding post. If the Miller circuit is hung up at the high end of the sawtooth the voltage at the front-panel binding post will measure about +200 volts; if hung up at the low end, the voltage at this point will measure anywhere between ground and —20 to —30 volts, depending on the cause.

If the Miller circuit is hung up at the high end of the sawtooth a check of the voltage at the grid of the Miller tube will offer a clue to the cause of the trouble. The static voltage at the Miller grid is determined by conduction through the Timing Resistor, R160 (from —150-volt bus), the lower diode V152B, and the divider R147-R148. It will be impossible to measure the exact voltage at the Miller grid because of the loading of the meter. However, if a 20,000-Ω/v meter, or a vacuum-tube voltmeter is used, the voltage reading obtained will be sufficient to indicate the source of the trouble. For example, if a voltage reading more negative than about —15 volts is obtained, there is probably no conduction through the Timing Resistor. This would indicate an open divider, R147-R148, assuming the diode V152 to be good.

If the Miller circuit is hung up at low the end of the sawtooth as indicated by a voltage reading of zero or a few volts negative, a check of the voltage at the plate of the Miller tube will offer a clue to the cause. If this voltage is quite high (about +350 volts), check the neon lamp B167 and the Runup CF tube V173. If the voltage at the plate of the Miller tube is zero or slightly negative, check for an open plate-load resistor R164, R165, or R166.

However, if the voltage at the plate of the Miller tube is near the quiescent level (about +45 volts) the trouble will generally lie ahead of the Miller tube. The result of the trouble is that the On-Off Diodes V152 cannot be gated off; they are conducting heavily and clamping the grid of the Miller tube near ground. If all of the tubes have been checked, then check for open plate and cathode resistors in the Sweep-Gating Multivibrator Circuit, the Hold-Off circuit and the Runup CF circuit. Also check that the STABILITY control can vary the voltage at the grid of V125.

Improper Triggering

If the sweep cannot be triggered properly, the gating pulse from the Multivibrator is not turning the diodes V152 off and on properly. The start of the gating pulse, which turns the diodes off and starts the sweep is initiated by the triggering pluse at the grid of V135A. The end of the gating pulse, which turns the diodes on and intiates the retrace, is controlled by the hold-off waveform at the grid of V135A. The Sweep-Gating Multivibrator can be eliminated as the cause of the trouble if the sweep can be turned off and on with the STABILITY control. The main component to check, in addition to the tubes, is the differentiating capacitor C131.

Nonlinear Sweep

A nonlinear sweep voltage will be generated if the current charging the Timing Capacitor C160 does not remain constant. If the nonlinearity occurs at all sweep rates a defective Miller tube will be the probable cause. If the nonlinearity occurs only at certain sweep rates a leaky Timing Capacitor will be the probable cause but the Miller tube should not be overlooked. A defective bootstrap capacitor C165 can cause the sweep to be nonlinear at the faster sweep rates.

Insufficient Horizontal Deflection

If the horizontal trace starts at the left side of the graticule, but does not extend to the right side, the Hold-Off circuit is causing V135A to conduct too soon after the triggering pulse has forced it into cutoff. If the trace cannot be expanded the full length of the graticule with the SWP. LENGTH control R176, check the resistance values in the cathode circuit of V173.

TROUBLESHOOTING THE HORIZONTAL AMPLIFIER

No Spot or Trace Visible on CRT

To determine that the Horizontal Amplifier is in a state of dc unbalance, short the horizontal deflection plates together at the neck pins of the crt in the manner explained for troubleshooting the Vertical Amplifier. The horizontal deflection plates are marked RED (LEFT) and GREEN (RIGHT). The INTENSITY control should be set to midscale. If a spot appears when the horizontal deflection plates are shorted together (it may be necessary to adjust the Vertical POSITIONING control), the trouble lies in the Horizontal Amplifier.

CAUTION

Do not permit the spot to remain on the crt at this setting of the INTENSITY control. Either reduce the intensity until the spot is just visible, or remove the short from the horizontal deflection plates.

The procedure for troubleshooting the Horizontal Amplifier to locate the defective stage, is similar to that explained for troubleshooting the Vertical Amplifier for unbalance. The shorting strap can be moved from the deflection plates back toward the Input Amplifier stage, until a point is reached where the trace does not appear. When the stage at fault is determined, check the defective tubes and components associated with that stage.

Insufficient or No Horizontal Deflection

If the gain of the Horizontal Amplifier decreases, the trace will not extend from the left to the right side of the graticule. In addition, the timing will no longer correspond to the Calibrated value indicated by the TIME/CM switch. (This is to distinguish the condition of insufficient sweep produced by a malfunction in the Horizontal Amplifier from the Hold-Off Circuit in the Time-Base Generator, e.g., an improper adjustment of the SWP. LENGTH control. In the latter case the trace will start at the left side of the graticule, for the normal setting of the HORIZONTAL POSITION control, and the timing will not be affected.)

If the change in gain is slight, as indicated by improper timing and a slightly decreased sweep, the amplifier can usually be recalibrated. Since the gain of the Horizontal Amplifier regulates the timing of the sweep, care must be taken to insure that the gain adjustments are accurately

made. Be sure to refer to the Recalibration Procedure if it is necessary to a adjust the gain of the Horizontal Amplifier.

If the decrease in gain of the Horizontal Amplifier is more pronounced, or if there is no sweep at all (in which case only a spot will be visible on the horizontal axis), check for defective components which can affect the gain but not the dc balance. In addition to the tubes, such components would be the common cathode resistors and controls.

TROUBLESHOOTING THE LOW-VOLTAGE POWER SUPPLY

Proper operation of every circuit in your instrument depends on proper operation of the Power Supply. The regulated dc voltages must remain within their specified tolerances for the instrument to retain its calibration.

CAUTION

Exercise care in checking the power supply. Because of their high-current capabilities and low impedance, the Low-Voltage supplies can produce more harmful shocks than the high-voltage supply in the CRT circuit.

Open Power Circuit (Dead Circuit)

If the pilot lamp and the fan do not come on when the power is turned on, check the source of power and the power cord connections. Check the fuse. If the fuse is blown replace it with one of the proper value and turn the instrument on again. If the new fuse blows immediately, check the power transformer for shorted primary or secondary windings. Also check for shorted rectifiers. If the new fuse does not blow until the time-delay relay has activated (a "click" can be heard), check for a shorted condition in the regulator circuits and the loading on the supply.

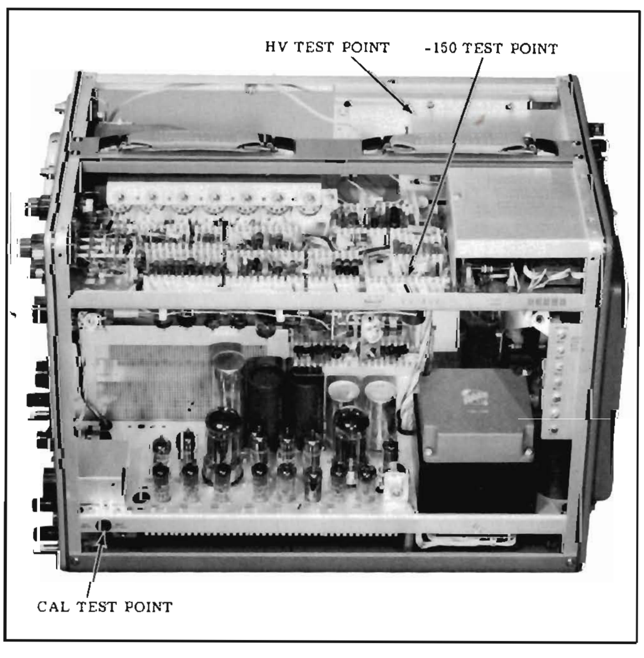


Fig. 5-12. Location of power supply and calibrator test points.

If the fuse is good, check for an open primary winding in the power transformer. If your instrument is wired for 234-volt operation, check for an open Thermal Cutout Switch; the resistance of this switch is about 0.1 Ω. (If your instrument is wired for 117-volt operation, the fan will come on even though the Thermal Cutoff Switch may be open.)

If both the fan and pilot light come on, the primary circuit of the power transformer is operating normally.

Incorrect Output Voltage

The voltage for each test point is silk-screened on the lip of the chassis adjacent to the ceramic strip on which the test points are located. Refer to Fig. 5-12 for a low-voltage check point location.

Each regulated bus is identified by a color-coded wire. The —150-volt bus is coded brown, green and brown on a black wire; the +100-volt bus is coded brown, black and brown on a white wire; the +225-volt bus is coded red, red and brown on a white wire; +350-volt bus is coded orange, green and brown on a white wire; and the +500-volt bus is coded green, black and brown on a white wire.

If any of the supplies fail to regulate the first thing to check is the line voltage. The supplies are designed to regulate between 105 and 125 volts with the design center at 117 volts, or between 210 and 250 volts with the design center at 234 volts, rms, 50-60 cycle single phase ac.

When possible, check the resistance values between the outputs of the Low-Voltage Power supplies and ground. Refer to your schematic diagram for the approximate resistance values.

If the resistance value between the regulated buses and ground check out, check the tubes (if this has not already been done). Then make sure that the line voltage is set near the design center for your instrument (117 or 234v) and check the rms voltage across the secondary winding for each supply; the nominal value of each secondary voltage, when the line is set to the design center, is indicated on the circuit diagram. If the secondary voltages are all correct, check the operation of the bridge rectifiers. This can be done by measuring the rectified voltage at the input to each regulator. These values are also indicated on the circuit diagram. Then check for off-value resistors, especially in the dividers, and for open or leaky capacitors.

The material that follows may be used as a quick index for troubleshooting the regulator circuits.

a. For high line voltage.

b. For open voltage-regulator tube.

c. The amplifier tubes in the regulator circuit.

d. For insufficient loading.

If the output voltage is high with normal ripple, check:

a. For proper resistance values in the dividers refer to the schematic for your instrument to determine the location of the resistors involved. Since these are generally precision resistors (±1% tolerance) the use of a good bridge is recommended in checking the value.

If the output is low with excessive ripple, check:

a. For low line voltage.

b. For shorted voltage-regulator tube.

c. The series tubes in the regulator circuit.

d. For excessive loading.

e. Open or leaky filter capacitors.

f. Defective rectifiers.

If the output is low with normal ripple, check:

a. The resistance values in the dividers.

b. The capacitors across the dividers.

NOTE

If any components in the —150-volt supply are changed, or if the setting of the —150 ADJ. control is changed, it will be necessary to recalibrate the instrument.

TROUBLESHOOTING THE CALIBRATOR

Asymmetrical Output

If the output square wave is not symmetrical (the positive portion has a duration different from that of the negative portion) the two tubes in the Multivibrator circuit are not being held cut off for equal periods. This will normally be caused by a defective tube. If tube replacement does not correct the waveform the circuit components must be checked. The pentode in the Multivibrator is held cut off for an intervial determined by the discharge of C871 and the triode is held cut off for an interval determined by the discharge of C874. A change in value of either capacitor, or in the value of the resistor through which they discharge, could produce an asymmetrical waveform.

In addition, the time needed for these capacitors to discharge a given amount is affected by the potential toward which they discharge; this would be the voltage at the plate of the triode in the case of C871, and the voltage at the screen of the pentode on the case of C874. Since these voltages are affected by the value of R870 and R875, these resistors should be checked. The resistors in the plate circuit of the pentode should also be checked, since they will affect the plate-to-screen ratio of the pentode.

Incorrect Output Voltage

The amplitude of the output square wave is determined almost entirely by the resistance values in the divider in the cathode-follower stage. A quick check of the resistance values can be made by turning off the Calibrator and measuring the voltage at the CAL. TEST PT: if this point does not measure exactly +100 volts the output voltages when the Calibrator is turned on will not be correct.

The CAL. ADJ. control R879 will vary the voltage at the test point over about a 10-volt range. If this voltage cannot be set to exactly +100 volts and if the tubes have been replaced, then one or more of the precision resistors in the divider have been changed in value.

TROUBLESHOOTING THE CRT CIRCUIT

The intensity, focus, geometry and calibration of crt display depend on proper operation of the high-voltage supplies in the CRT Circuit.

No Intensity

If the low-voltage power supply is operating normally, but no spot or trace is visible on the crt, the trouble could be a defective crt, a defect in the crt cathode circuit including the supply, or an unbalanced dc condition in either or both of the deflection amplifiers. In the latter case the dc unbalance is producing improper positioning voltages and the beam is being deflected off the screen.

To determine which circuit is at fault, turn the INTENSITY control full right (cw). If a flare is observed on the crt screen (it may be necessary to darken the room), one of the deflection amplifiers is probably at fault; the procedure for troubleshooting these circuits follows a bit later in this section. If no flare is observed with the INTENSITY control turned full right the trouble will either be due to a defective crt or to an inoperative cathode supply circuit. The cathode supply can be checked by measuring the voltage at the HV ADJ. TEST POINT. In the majority of instruments the test point is located at the top left rear of the instrument. Fig. 5-12 shows the location of typical high-voltage test points. Refer to the schematic diagrams for your instrument to determine the correct voltage. If the voltage reading you obtain is in the vicinity of the correct voltage noted on the schematic, turn the instrument off, and measure the value of the 27K resistor attached to the test point (see Fig. 4-10). If this resistor is not open a defective crt is indicated.

If the voltage at the HV ADJ. TEST POINT is zero or abnormally low replace the Oscillator tube and the Error-Signal Amplifier tube. If this does not restore operation the Oscillator circuit should be checked.

A quick check on the operation of the Oscillator circuit can be made by observing the heater glow in the 5642 rectifier tubes, located under the shield at the upper right rear of the instrument. These tubes are visible through the opening in the side of the shield. If no heater glow is visible the Oscillator circuit is inoperative. This could be due to an open high-voltage transformer, or to a defective component in the oscillator of error-signal amplifier circuits.

If heater glow is visible in the rectifier tubes, the Oscillator circuit is operating. If the heater glow appears to be dim, however, the output of the Oscillator may be insufficient for proper operation. A more accurate check on the Oscillator may be made by removing the shield covering the high-voltage transformer and measuring the bias at the grid of the oscillator tube. This can be measured at the junction of the 100 k resistor and the 0.01 μfd. capacitor See the simplified schematic, Fig. 4-10, for the normal circuit configuration in the high-voltage oscillator. The voltage at this point should measure about —65 volts.

CAUTION

Do not let your hand or body touch the chassis when making this check. Secondary reactions to an otherwise harmless shock might result in a painful injury.

If the Oscillator circuit is operating properly, but the voltage at the HV ADJ. TEST POINT does not measure in the vicinity of that indicated on the schematic diagram for the instrument, the 5642 rectifier tube, V822, shown in the simplified schematic of Fig. 4-10 is most likely defective.

If a trace is visible on the crt, the relative intensity of the trace may be used to identify trouble in either the negative bias supply or the positive anode supply.

If the trace is excessively brilliant, and if the brilliancy does not change as the INTENSITY control is adjusted, check the negative bias supply including the lead to the first grid of the crt. Check for a defective rectifier tube V822, (shown in the simplified schematic diagram of Fig 4-10), an open supply winding, an open resistor including the INTENSITY control, or a shorted or leaky capacitor. If trouble is not found in any of these components, a defective crt is indicated.

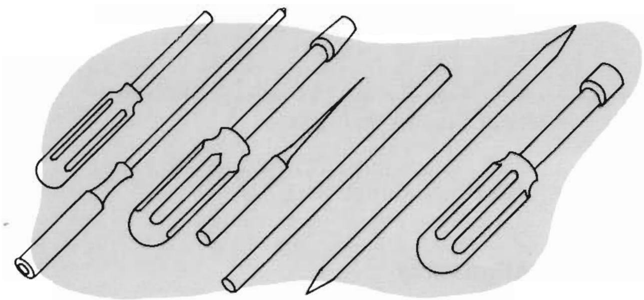
If the intensity of the trace is extremely low, check for an inoperative positive supply. Also check the anode connection to the crt, including R836 and C836.

If the accelerating potentials appear to be too high, as evidenced by decreased deflection sensitivity, check the Error-Signal Amplifier circuit.

If a badly distorted trace or spot is visible on the crt, check the GEOM. ADJ. control and its connection to the neck pin on the crt, and the ASTIGMATISM control and its connection to the crt base socket. If the FOCUS control has no effect on the trace, check this control and its connection to the crt base socket.

NOTE

If any components in the Oscillator, Error-Signal Amplifier or cathode supply circuit are changed, or if the setting of the HV. ADJ. control is changed it will be necessary to recalibrate the instrument.



SECTION 6

CALIBRATION PROCEDURE

EQUIPMENT REQUIRED

The following equipment is required for a full recalibration of the Type 531A.

1. DC voltmeter (sensitivity at least 5000 Ω/v) calibrated for accuracy of at least 1% at 100, 150, 225, 350 and 500 volts, and for an accuracy of 3% at 1350 volts. Be sure the meter is accurate. Few portable meters have comparable accuracy, particularly after a period of use.
2. Accurate rms-reading ac voltmeter, 0-150 volts (0-250 or 0-300 volts for 234-volt operation).
3. Variable autotransformer (Powerstat, Variac, etc) having a rating of at least 6.25 amperes.
4. Time-Mark Generator, Tektronix Type 180 or Type 180A or equivalent. Time-Mark Generator used must have markers at 1 μsec,, 10 μsec, 50 μsec, 100 μsec, 1 msec, 5 msec, 100 msec, 1 sec and 5 sec and sine-wave output of 10 cm and 50 cm, with accuracy of at least 1%.
5. Constant-Amplitude Signal Generator, Tektronix Type 190 or 190A. Signal Generator used must provide a 200-millivolt signal variable in frequency from 500 kc to over 15 mc. The signal amplitude must remain constant (200 mv) over the entire frequency range.
6. Low-Capacitance Recalibration tools: Part numbers 003-000, 003-301 and 003-007.
7. Type K Plug-In Unit

   If a Type K Unit is not available, another of the Tektronix preamplifier-type plug-in units may be used. Variations in the Recalibration Procedure, when a Type K Unit is not used, are explained at the appropriate time.
8. Type P Plug-In Unit, or a Square-Wave Generator, Tektronix Type 107 or equivalent. The Tektronix Type P Unit is designed especially for adjusting the Delay Line and high frequency compensating circuits in the Type 531A. If a Type P Unit is not available, a fast-rise Square-Wave Generator, having a rise time of no more than 3 nanoseconds, may be used. A B52-R Terminating Resistor is required if the Type 107 or equivalent is used.

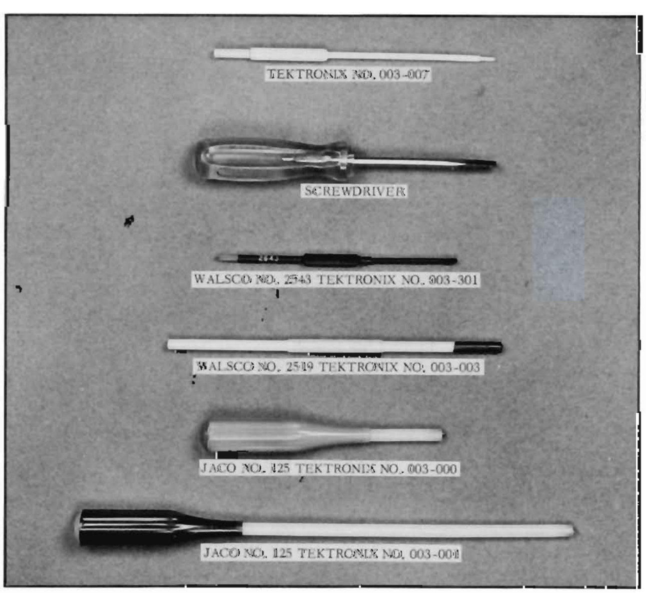


Fig. 6-1. Suggested Calibration tools.

ADJUSTMENT PROCEDURE

Preliminary

Remove the side covers and the bottom plate from the oscilloscope and install the Type K (or other type plug-in) Unit. Set up the front-panel controls as follows:

Type 531A

INTENSITY	full left (ccw)
TRIGGER SLOPE	+INT.
TRIGGERING MODE	AUTOMATIC
TIME/CM	.5 MILLISEC
VARIABLE	CALIBRATED (full right)
HORIZONTAL DISPLAY	NORMAL
CALIBRATOR	OFF

Plug-In Unit

The following controls are those associated with the Type K Plug-In Unit; the nomenclature will differ slightly with other types:

AC/DC	DC
VOLTS/CM	.05
VARIABLE	CALIBRATED (full right)

Note: For those controls not listed, their adjustment is not pertinent to this part of the procedure and the controls may be left in any position. Adjustment of these controls will be made at the appropriate time in the following procedure.

Check the rear of the instrument to be sure the ground strap is connected between the GRD. and EXTERNAL CRT CATHODE binding posts, and that the CRT CATHODE SELECTOR switch is turned away from the DUAL-TRACE CHOPPED BLANKING position. Connect the Type 531A to the autotransformer, and turn on all equipment. Set the output of the autotransformer to the design center voltage for which your instrument is wired (117 v or 234 v). Allow at least five minutes for warmup before making any adjustments.

If the instrument fails to calibrate in any of the following steps, refer to the Troubleshooting Procedure section of the manual for infomration concerning the circuit involved.

POWER SUPPLY, CALIBRATOR AND CRT CIRCUIT

(1) —150-Volt Adjust

Connect voltmeter to —150-volt bus at the test point indicated on the upper chassis on the right side of the instrument. Adjust the —150 ADJ. control for a reading of exactly —150 volts. Use a voltmeter you know to be accurate. Check voltage on +100, +225, +300 and +500-volt buses; all should be within 3% of its rated value. If any of the regulated buses that must measure with 3% of its rated value does not measure between these limits, readjust the —150 ADJ. control until the voltage measures within specifications. At the final setting of the —150 ADJ. control, the —150-volt bus must measure between —147 and —153 volts (±2%).

Check regulation of each bus by varying line voltage between 105 and 125 volts (or 210 and 250 volts); all regulated voltages should remain constant over this range.

(2) Calibrator

Connect voltmeter to CAL. TEST POINT (make sure calibrator is turned off). Adjust CAL. ADJ. control for reading of +100 volts. Turn Calibrator on (to any output voltage); voltage at test point should fall to +50 ±5 volts.

(3) —1350-Volt Adjust

Connect voltmeter to HV. ADJ TEST POINT. Adjust HV. ADJ. control for reading of exactly —1350 volts. (If your voltmeter has a 1200-volt scale, connect common lead of voltmeter to —150-volt bus, and adjust HV. ADJ. for dial reading of 1200 volts.) This voltage should not vary more than 10 volts between the following limits:

Lower limit: Line voltage 105 volts (or 210 volts)
INTENSITY control full right.

Upper limit: Line voltage 125 volts (or 250 volts)
INTENSITY control full left.

(4) CRT Alignment

Turn up INTENSITY control until trace is visible (it may be necessary to adjust the Vertical Positioning control on the plug-in unit) and adjust FOCUS and ASTIGMATISM for sharpest trace (narrowest trace width). Position trace directly behind center graticule line. If the trace and graticule line do not coincide over the length of the graticule, loosen the crt base clamp and rotate the tube with the alignment ring. When the trace and the graticule line are in coincidence, push the tube forward so that it rests snugly against the graticule. Then tighten the crt base clamp. Recheck the alignment after tightening the clamp to be sure it didn't move while the clamp was being tightened.

(5) Graticule Alignment

Position the trace directly behind the center graticule line; then using a screwdriver with an insulated handle (or a shorting strap) short the vertical deflection plates together at the neck pins on the crt. These are the plates marked BLUE (UPPER) and BROWN (LOWER). Be careful not to short the pins to the crt shield. Observe the vertical position of the trace on the crt when the vertical deflection plates are shorted together; this is the electrical center of the crt. If the electrical center of the crt does not coincide with the center line of the graticule, remove the short from the deflection plates and position the trace to the electrical center. Remove the graticule cover and loosen the set screw in the nylon cam in the lower left corner of the graticule. Check to be sure the trace is at the electrical center of the crt, and position the center line of the graticule to coincide with the trace. Tighten the set screw in the positioning cam and replace graticule cover.

(6) CRT Geometry

Connect a test lead from the CAL. OUT connector to the INPUT connector on the plug-in unit, and set the CALIBRATOR for an output of 0.5 volt. Position the display vertically so that only the rising and falling portions of the signal are visible on the crt (it may be necessary to reduce the ambient light to see the trace). Adjust the INTENSITY, FOCUS and ASTIGMATISM controls for best definition; then adjust the GEOM. ADJ. control for minimum curvature in the vertical traces. (See Fig. 6-2.)

TRIGGERING CIRCUITS

Reset front-panel controls as follows:

Type 531A

STABILITY	full right (cw)
TRIGGERING LEVEL	0

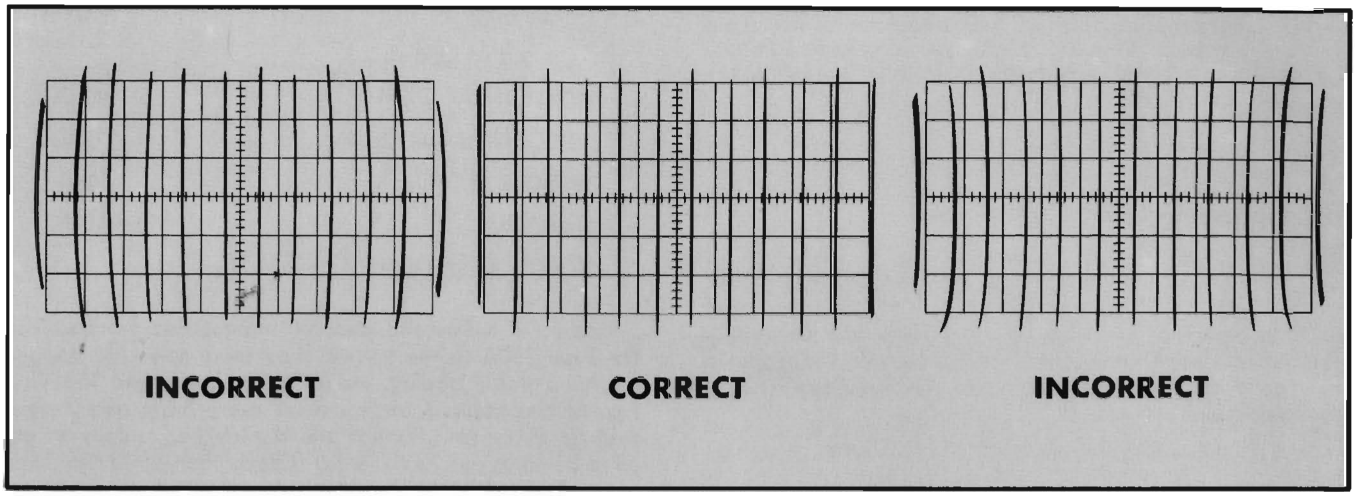


Fig. 6-2. Adjustment of the Geometry control.

TRIGGERING MODE	AC
TRIGGER SLOPE	+INT.
TIME/CM	.5 MILLISEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	NORMAL
CALIBRATOR	10 MILLIVOLTS

Plug-In Unit

AC/DC	DC
VOLTS/CM	.05
VARIABLE	CALIBRATED

Connect a test lead from the CAL. OUT connector to the INPUT connector on the plug-in unit; this should result in a free-running trace having an amplitude of about 2 millimeters (1 minor division). Center the trace vertically on the screen and adjust the INTENSITY, FOCUS and ASTIGMATISM controls for best definition. Then ground the junction of R19, R20 and C20 with a short clip lead. This junction is located on top of the Trigger switch (see Fig. 6-3).

Preset the TRIGGER SENSITIVITY control full left (ccw) and the TRIGGERING LEVEL CENTERING control full right (cw). Turn the STABILITY control left until the trace just disappears from the crt screen, then two or three degrees further left.

Turn the TRIGGERING LEVEL CENTERING control to the left until the display reappears on the screen. If the display does not appear, turn the TRIGGER SENSITIVITY control to the right a few degrees, and repeat the adjustment of the TRIGGERING LEVEL CENTERING control until the display reappears. Reduce the amplitude of the signal by turning the VARIABLE gain control on the plug-in unit slowly toward the full left position, at the same time continuing the adjustment of the TRIGGERING LEVEL CENTERING and TRIGGER SENSITIVITY controls to keep the trace on the screen. Then switch the TRIGGER SLOPE control to —INT; it may be necessary to turn the TRIGGERING LEVEL CENTERING control to obtain a display. Then set the TRIGGERING LEVEL CENTERING control halfway between the settings at which the waveform is stable in the +INT. and —INT. positions (the TRIGGER SLOPE switch may be left in either position) and adjust the TRIGGER SENSITIVITY control slowly to obtain a stable display. Then while switching back and forth between +INT. and —INT., slightly readjust both the TRIGGERING LEVEL CENTERING and TRIGGER SENSITIVITY controls for stable triggering in both positions.

(7) Internal Trigger DC Level

Increase the setting of CALIBRATOR to 20 millivolts. Return the VARIABLE gain control to the CALIBRATED position, center the display vertically, and turn the TRIGGERING MODE switch to the DC position. Then, while switching the

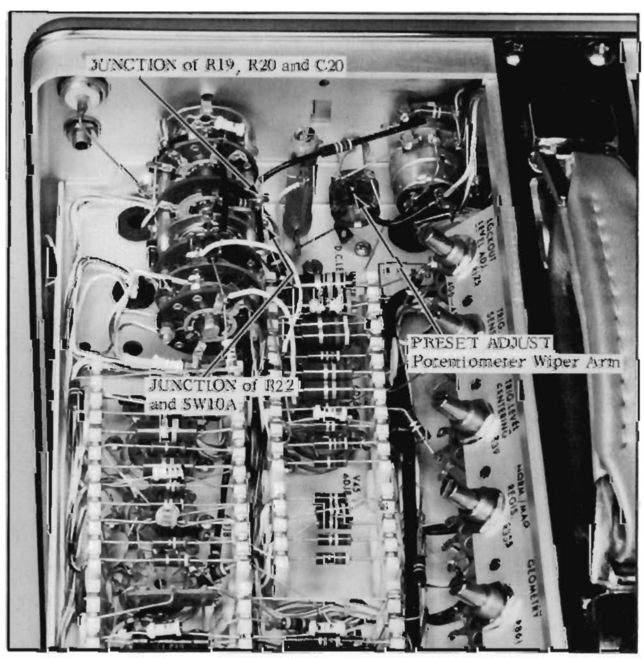


Fig. 6-3. Location of Trigger Circuit test points.

TRIGGER SLOPE control back and forth between +INT. and —INT., adjust the Int. Trig., DC Level Adj. control for stable triggering in both positions. It may be necessary to slightly adjust the VERTICAL POSITION control to obtain stable triggering.

(8) Triggering Level

Remove the jumper and turn the TRIGGERING LEVEL control until the waveform is triggered at the same point as that observed when the shorting lead was connected. The white dot on the TRIGGERING LEVEL knob should now point at 0. If it doesn't loosen the knob and move it to this position.

(9) Preset Stability and Automatic Triggering

Leave setup unchanged from previous step except for the following: Remove the test lead connecting the CAL. OUT and vertical INPUT connectors, and set the TRIGGERING MODE switch to the AUTOMATIC position. Set the PRESET ADJUST control (screwdriver adjustment, front panel) to its full left position and connect a voltmeter between the center arm of the PRESET ADJUST control to the right until a trace is just visible on the crt; note voltmeter reading for this setting of the control. Then, advance the PRESET ADJUST control further right until the trace brightens and note the voltmeter reading for this setting. Finally, back off the control until the voltmeter indicates a reading midway between the two previous readings.

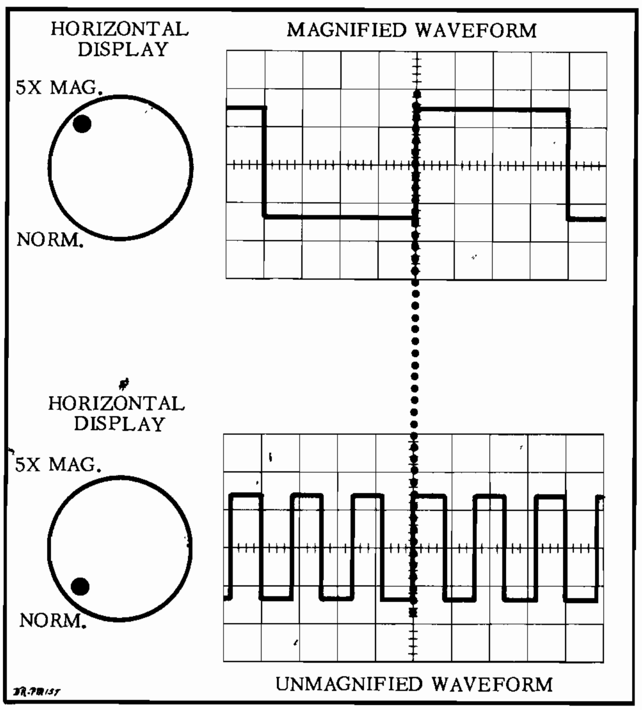


Fig. 6-4. When the NORM/MAG REGIS. control is adjusted properly, the portion of the displayed waveform at the exact center of the graticule remains stationary as the magnifier is turned on and off.

(10) Adjust 5X Magnifier Gain

Set controls as follows:

HORIZONTAL DISPLAY	5X MAG.
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT.
TIME/CM	1 MILLISEC
VOLTS/CM (Plug-In)	2

Connect 1 millisecond and 100 microsecond markers from the Type 180A to the vertical input and adjust the triggering for a stable display. Adjust MAG. GAIN (see Top View Fig.6-5) to display 1 large marker every 5 cm, and 2 small markers every cm. Position the display horizontally to observe linearity on both ends. Check that the neon lamp lights when MAGNIFIER is switched on.

(11) Adjust Sweep Magnifier Registration

With the HORIZONTAL DISPLAY switch at 5X MAG., position the display so that the first time marker is directly behind the center graticule line. Turn the HORIZONTAL DISPLAY switch to NORM. and adjust NORM./MAG REGIS. (see Fig. 6-4) so that the first time marker again falls directly behind the center graticule line.

(12) Adjust External Horizontal DC Balance

Connect a jumper from the SAWTOOTH OUT to the vertical INPUT, switch the HORIZONTAL DISPLAY to EXT. HORIZ. ATTEN. X1 and turn STABILITY full right. Turn the HORIZONTAL POSITION control to the left to position a vertical trace to the left vertical graticule line. Now, adjust the EXT. HORIZ. AMP. DC BAL. (see Top View, Fig.6-5) control for no horizontal shift of the trace while turning the horizontal EXTERNAL HORIZ. ATTENUATOR 10-1 front-panel control.

(13) Check EXT. HORIZ. INPUT Deflection Factor

With conditions as in Step 12 above, connect a jumper from CAL. OUT to HORIZ. INPUT, set CALIBRATOR for .2 volt and then turn the EXTERNAL HORIZ. ATTENUATOR 10-1 control full right. At least one centimeter of horizontal deflection must be observed between the two vertical lines. Increase the CALIBRATOR to 2 VOLTS and adjust EXTERNAL HORIZ. ATTENUATOR 10-1 for exactly 10 cm of horizontal deflection between the vertical lines. Now switch HORIZONTAL DISPLAY to EXT. HORIZ. ATTEN. X10. Horizontal deflection should now be 1 centimeter. (Attenuator accuracy ±2%.)

(14) Adjust External Horizontal Input Compensation

Connect a jumper from the SAWTOOTH OUT to the vertical INPUT. Feed .5 VOLT from CAL. OUT. to both HORIZ. INPUT and TRIGGER INPUT. Set controls as follows:

HORIZONTAL DISPLAY	EXT. HORIZ. ATTEN. X1
TRIGGER SLOPE	—EXT.
TIME/CM	1 MILLISEC
VOLTS/CM (Plug-In)	10

Adjust STABILITY and TRIGGERING LEVEL controls for a stable square-wave, displayed vertically. Adjust C330 (see Top View, Fig. 6-5) for optimum square-wave response. Now switch the HORIZONTAL DISPLAY to EXT. HORIZ. ATTEN. X10, increase CALIBRATOR signal to 5 VOLTS, and adjust C301C (see Right Side View, Fig. 6-6) for optimum flattop.

(15) Adjust Sweep Calibration

Set controls as follows:

HORIZONTAL DISPLAY	NORM.
TIME/CM	1 MILLISEC
TRIGGERING MODE	AC
TRIGGERING SLOPE	+INT
VOLTS/CM (Plug-In)	2

Connect 1 millisecond markers from the Type 180A to the vertical INPUT and adjust triggering for a stable display. Adjust SWEEP CAL (see Right Side View, Fig. 6-6) for 1 time-marker per centimeter.

NOTE

Any non-linearity present in the sweep will always be in the first and last centimeter. Consequently, all timing adjustments should be made from the 1 cm line to the 9 cm line in the graticule.

(16) Adjust Sweep Length

With controls as in Step 15 above, adjust the SWEEP LENGTH control (see Top View, Fig. 6-5) for a sweep length of 10.5 centimeters.

(17) Check Sweep Rates

Starting with conditions as in Step 15 above, check the sweep rates according to the following table:

TIME/CM	TYPE 180A	Markers displayed
1 MILLISEC	1 MILLISECOND	1/cm
2 MILLISEC	1 MILLISECOND	2/cm
5 MILLISEC	5 MILLISECOND	1/cm
10 MILLISEC	10 MILLISECOND	1/cm
20 MILLISEC	10 MILLISECOND	2/cm
50 MILLISEC	50 MILLISECOND	1/cm
.1 SECOND	100 MILLISECOND	1/cm
.2 SECOND	100 MILLISECOND	2/cm
.5 SECOND	500 MILLISECOND	1/cm
1SECOND	1 SECOND	1/cm
2 SECOND	1 SECOND	2/cm
5 SECOND	5 SECOND	1/cm

(18) Check VARIABLE TIME/CM Control and UNCALIBRATED Neon.

The VARIABLE control provides for a complete range of control between the calibrated TIME/CM steps. To check operation of this control, set TIME/CM to 1 MILLISEC—CALIBRATED, connect 5 MILLISECOND markers from the Type 180A to the Vertical INPUT and trigger the oscilloscope for a stable display consisting of 1 marker for each 5 cm. Next, turn the VARIABLE control full left. The display should now consist of markers every 2 cm or less. Check to see that the UNCALIBRATED neon indicator lamp is lit in all positions of the VARIABLE control except when switched to the CALIBRATED position.

(19) Adjust Sweep Rates 50 μsec/cm to .02 μsec/cm

Set TIME/CM to .1 MILLISEC, apply 10 MICROSECOND markers from the Type 180A to the Vertical INPUT, and adjust the triggering for a stable display. Turn the HORIZONTAL DISPLAY switch to 5X MAG. and horizontally position the trace so that the first time marker is aligned with the center graticule line. Then switch the TIME/CM switch to 50 μsec and check for horizontal shift of the first marker. If shift occurs, adjust C330 (see Top View, Fig. 6-5) until the first marker of both the .1 MILLISEC and 50 MICROSEC positions occur at the same point.

Turn the HORIZONTAL DISPLAY switch to NORM., TIME/CM to 10 μSEC and proceed with the following adjustments:

TIME/CM	TYPE 180A	Adjustments	Observe
10 μSEC	10 MICROSECOND	C160E	1 marker/cm.
1 μSEC	1 MICROSECOND	C160C	1 marker/cm.
.5 μSEC	1 MICROSECOND	C160A	1 marker/2 cm Position 2nd marker to 2nd line on graticule.
.1 μSEC	10 MC	†C375 for linearity and C348 for time	1 cycle/cm
2 μSEC	1 MICROSECOND	Check timing range	2 markers/cm
5 μSEC	5 MICROSECOND	Check timing range	1 cycle/cm
.1 μSEC	50 MC*	C364 and C384 (See Fig. 6-5)	1 marker/cm

† C375 only effects the first part of the display. There is considerable reaction between C348 and both C160A and C160C. The adjustments of C348 and C160A should be repeated back and forth several times to obtain optimum linearity with correct timing, after which C160C should be readjusted if necessary. Timing adjustments should be made, as usual, between the first and ninth centimeter lines of the graticule

* Couple 50 MC from Type 180A through a small capacitor (100 μμf) directly to one of the vertical plates of the crt. C364 and C384 should be set as nearly at the same capacity as possible. It may be necessary to slightly readjust C374 to obtain best possible linearity.

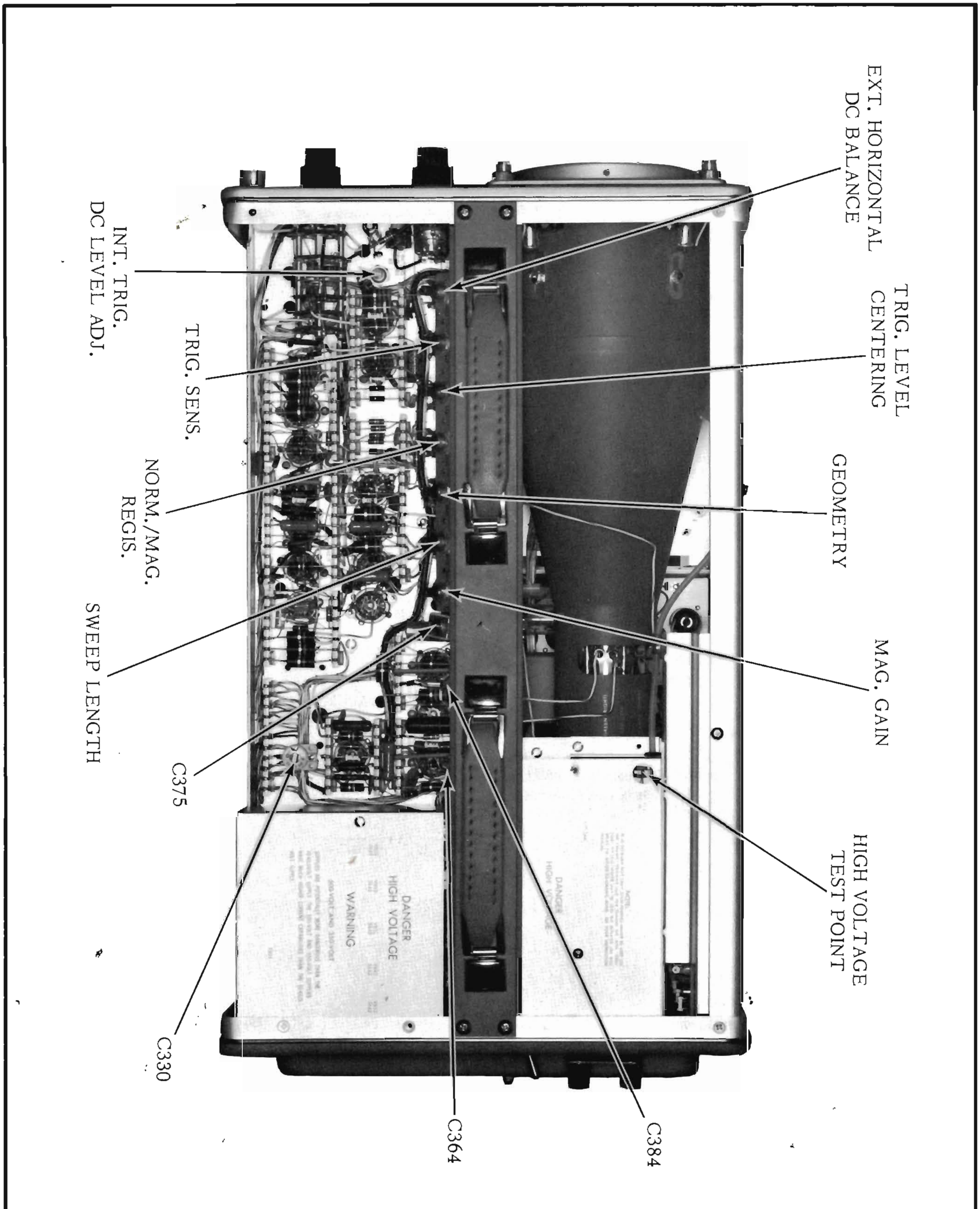


Fig. 6-5. Top view of the Type 531A Oscilloscope showing the location of calibration controls.

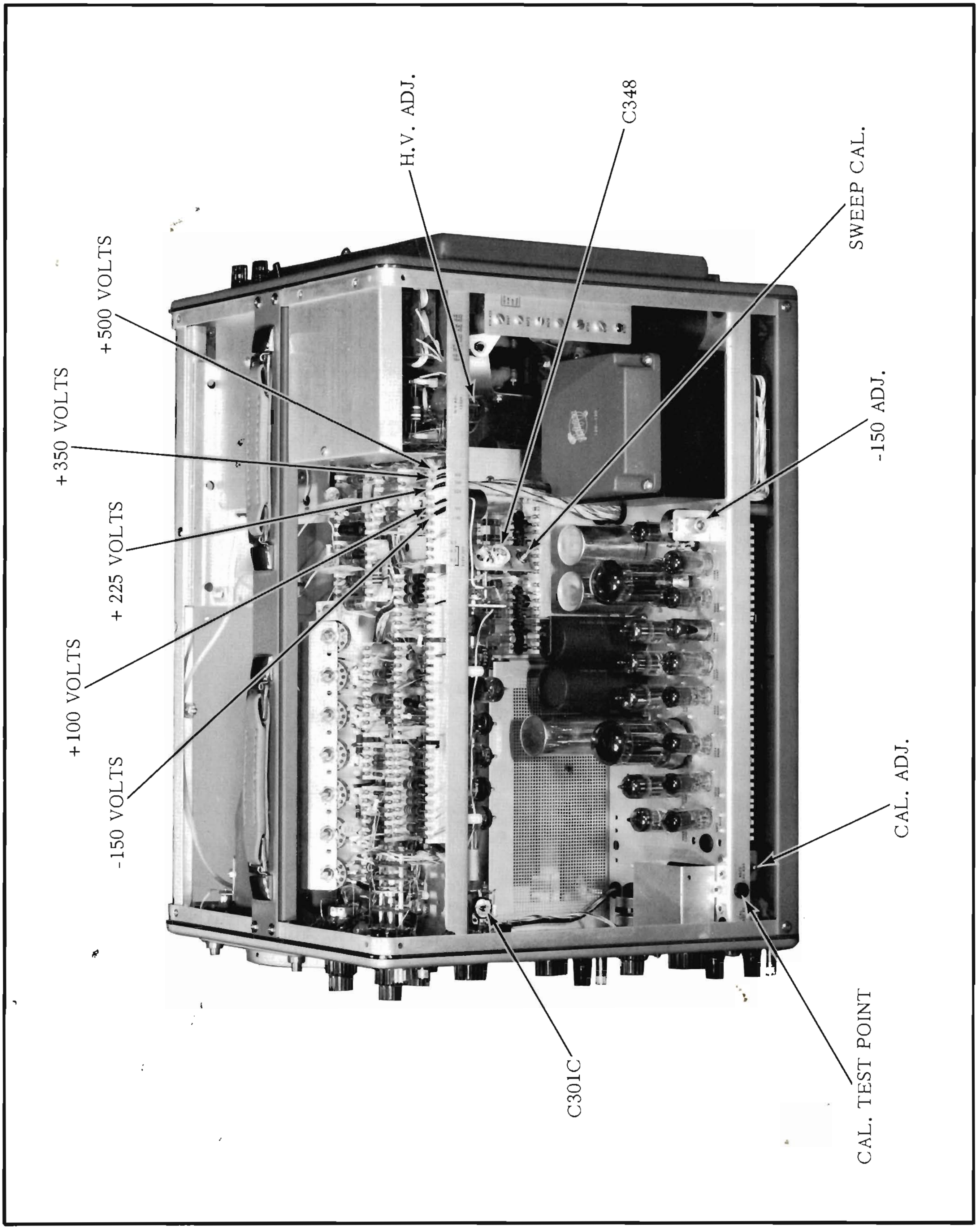


Fig. 6-6. Right side view showing the location of calibration controls.

VERTICAL AMPLIFIER

Set up front-panel controls as follows:

Type 531A

TRIGGERING MODE	AUTOMATIC
TRIGGER SLOPE	+INT.
TIME/CM	.5 MILLISEC
HORIZONTAL DISPLAY	NORMAL
CALIBRATOR	100 MILLIVOLTS

Plug-In Unit

AC/DC	DC
VOLTS/CM	.05
VARIABLE	CALIBRATED (full right)

Before proceeding with the calibration of the Vertical Amplifier the dc balance of the plug-in unit should be checked. Rotate the VARIABLE control; if any vertical displacement of the trace is apparent adjust the DC BAL control (accessible through the front panel) until the trace remains stationary as the VARIABLE control is rotated. (On some plug-in units this control is called VARIABLE ATTEN. BAL.) Be sure to return the VARIABLE control to the CALIBRATED position after completing the adjustment. IMPORTANT NOTE: Be sure the plug-in unit used for the following adjustment has been correctly calibrated for gain.

(20) Vertical Amplifier Gain

Apply 100 millivolts of signal from the Calibrator to the Vertical INPUT connector. Adjust the GAIN ADJ. control R570 for exactly 2 centimeters of vertical deflection. NOTE: This is the GAIN ADJ. control for the main Vertical Amplifier, not the one for the plug-in unit. The GAIN ADJ. control R570 is accessible from the upper side of the Vertical Amplifier chassis.

DELAY LINE AND HIGH-FREQUENCY COMPENSATION

This section describes two methods for adjusting the Delay Line and high-frequency compensation of the Type 531A Oscilloscope. The first and preferable method requires a Tektronix Type P Plug-In Test Unit, which generates a fast-rise step function of known characteristics. This signal simulates the output of an ideally compensated Type K Preamplifier Plug-In Unit driven by a Tektronix Type 107 Square-Wave Generator. The Type P Unit permits the standarization of the main Vertical Amplifier and Delay Line transient response of Type 531A (and other Tektronix convertible-type) Oscilloscopes. After standardization, the Type 531A (or other convertible-type oscilloscope) may be used in conjunction with a Type 107 Square-Wave Generator to standardize the transient response of preamplifier-type plug-in units. Standardized oscilloscopes and plug-in units may then be used interchangeably without readjustment of the high-frequency compensating circuits.

The other method requires a properly adjusted Type K (or other fast-rise, wide-band preampliifer) Plug-In Unit and a Tektronix Type 107 (or equivalent) fast-rise Square-Wave Generator. Unlike the first method, this method is used to compensate the main Vertical Amplifier and Delay Line to match the plug-in unit being used. Depending on the adjustment of the plug-in unit employed, the oscilloscope may or may not be suited for use with other plug-in units, in high frequency applications, if this method is used. This method is entirely satisfactory, however, if the same plug-in unit (the one employed during the adjustment procedure) is used with the oscilloscope.

(21) Method Using Type P Plug-In Unit

Install the Type P Unit in the Type 531A and position the oscilloscope physically so that either of the UP arrows on the P Unit points upward. Set the front-panel controls as follows:

Type 531A

STABILITY	full right
TRIGGERING LEVEL	full right
TRIGGERING MODE	AC LF REJECT
TRIGGER SLOPE	+INT.
TIME/CM	.2 μSEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	NORMAL

Type P Unit

COIL CURRENT	ON
AMPLITUDE	White dot at 3 o'clock

Adjust the COIL CURRENT ADJUST control for the loudest steady hum, and adjust the INTENSITY and VERTICAL POSITION controls so that the two free-running traces are visible on the crt. Then turn the STABILITY control to the PRESET position and advance the INTENSITY control until two spots are just barely visible at the left side of the graticule (it may be necessary to adjust the HORIZONTAL POSITION controls to properly position the spots). Turn the TRIGGERING LEVEL control slowly toward the 0 position until a waveform similar to Fig. 6-7 is obtained. Readjust the AMPLITUDE control for a deflection of about 3 centimeters, adjust the INTENSITY, FOCUS, and ASTIGMATISM controls for sharpest detail, and position the waveform as shown in Fig. 6-7.

The unretouched photograph of Fig. 6-7(a) shows the P-Unit waveform on a properly adjusted Type 531A Oscilloscope. The flat, level top indicates proper adjustment of the Delay Line and the termination network, and the fast rise and square corner indicate proper adjustment of the peaking circuits in the amplifier ahead of the line. Fig. 6-7(b) shows the same waveform except for a small aberration in the top about 2 centimeters to the right of the leading corner. This aberration is known as the "termination bump", and was obtained by detuning the Delay Line termination network (C553-C563) slightly. The oscilloscope was adjusted

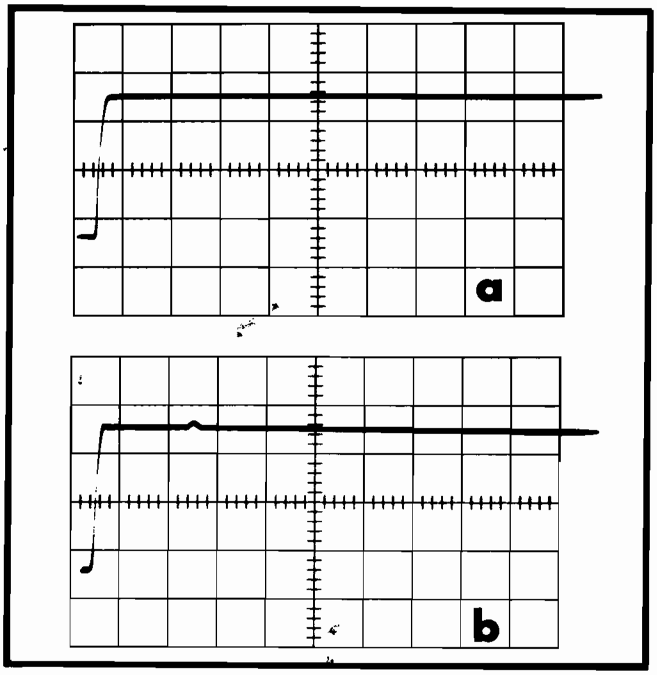


Fig. 6-7. (a) The Type P Unit waveform displayed on a properly adjusted Type 531A; (b) the same waveform showing the termination bump.

for a sweep rate of 0.2 μsec/cm for these photographs; the termination bump therefore occurs 0.4 microsecond after the leading corner. Since the Delay Line is reverse terminated, this corresponds to twice the 0.2-microsecond delay of the circuit.

If the P-Unit waveform, when displayed on the Type 531A, does not appear as shown in Fig. 6-7(a) the Delay Line and/or peaking circuits are in need of adjustment.* The following facts should be remembered when adjusting the circuit:

1. The Delay Line is reverse-terminated (R553-R563). The Delay-Line capacitors nearest the crt will affect the start of the pulse, i.e., the leading corner. The Delay-Line capacitors nearest the Vertical Amplifier will affect the pulse in the region of the termination bump.
2. The delay time of the line is 0.2 μseconds; but since the line is reverse-terminated, the termination bump will appear 0.4 μseconds after the corner.
3. The termination bump is affected by the adjustment of the termination network (C553-C563), however the termination network also affects the corner of the pulse.
4. The peaking adjustment ahead of the termination network and those at the crt deflection plates affect the leading corner of the waveform.

*See also "Waveform Distortion" in the Maintenance section of this manual.

Minor Adjustment Required

A minor adjustment of the Delay Line and/or peaking circuits will be required only when the leading corner is rounded off or has a slight overshoot, when aberrations appear both at the leading corner and in the vicinity of the termination bump, or when there are slight aberrations in the top of the pulse (similar to those shown in Fig. 5-10(c). By analyzing the type of distortion according to the information presented in the preceding paragraph and that presented in the Trouble-Shooting Procedure (under Waveform Distortion), it is generally an easy matter to locate the components that have been misadjusted and correct their adjustment.

ADJUSTMENT PROCEDURE

Major Adjustment Required

A major adjustment of the Delay Line and peaking circuits may be required:

1. If the Delay Line and/or Vertical Amplifier have been replaced;

2. If the instrument has been subjected to severe vibration;

3. If the adjustments have been tampered with.

There are four steps involved in making a major adjustment of the Delay Line and the Vertical Amplifier:

1. Presetting the adjustments;
2. Establishing a level display;
3. Removing the "wrinkles" in the top of the pulse;
4. Compensating the amplifier.

Presetting the Adjustments

If the displayed pulse on the crt indicates that the Delay Line and peaking circuits are considerably out of adjustment, presetting the controls before starting the adjustment procedure will generally render the best results.

The variable inductors L506 and L523, located in the plate circuit of the Input Amplifier, should be preset so that the cores are positioned deeper into the coil forms than the windings of the coils extend. L553 and L563, located in the plate circuit of the Output Amplifier, each has two cores...an inner core and an outer core. The inner core can be reached by using the small end of alignment tool 003-301. The inner cores should be positioned deeper into the coil forms than the windings of the coils extend; the outer cores should be positioned just out of the windings. The two variable inductors at the crt end of the line (L955 and L956) should be preset so that the cores are also just out of the windings. By presetting the inductors in this manner their effect in the circuit is reduced and the adjustment of the Delay Line is simplified.

The variable capacitors in the delay line should be preset so that the top of the adjusting screw extends about one-quarter of an inch above the top of the contact springs, or if preferred about three-eights of an inch above the body of the capacitor. The important characteristic is that the tops of all adjusting screws should be at the same height, both after the preset procedure and after the final adjustment.

The capacitors in the termination network (C553-C563) are the first to be adjusted in the adjustment procedure; for this reason it is unnecessary to preset these adjustments.

Establishing a Level Display

The reference level for the displayed waveform is established by that portion of the pulse following the termination bump. The first step, therefore is the adjustment of the termination network. Observe the pulse closely about two centimeters to the right of the leading corner, and adjust C553 and C563 for the minimum termination bump.

The level of that portion of the pulse preceding the termination bump is determined by the collective effect of L553 and L563, and all the Delay-Line capacitors. The top of the pulse should be level (not necessarily wrinkle-free at this time); that is, there should be neither an upward nor downward slant to the top of the pulse between the termination bump and the corner. The level can best be checked by reducing the sweep rate to about 20 μSEC/CM; this reduces the width of the top of the pulse and "crowds" the wrinkles into a smoother display. The reduction in pulse width makes any departure from a level of the display more easily observed.

To improve the level of the display, adjust L553 and L563 (both cores) until the top of the waveform adjacent to the termination bump is level. Then, starting with the Vertical Amplifier end of the Delay Line, adjust each capacitor a small amount, carefully observing the top of the waveform for the result. Be sure to retain a level top when progressing toward the crt end of the line.

After making the preceding adjustments and establishing an average level for the display, advance the sweep rate to 2 μSEC/CM and repeat the procedure. This time, try to adjust the inductors and capacitors for a smooth transition from bump to bump, at the same time maintaining the level. Do not try to obtain a wrinkle-free display at this time; just try to reduce the amplitude of all the bumps the same amount. The important consideration is to retain the level of the display.

Removing the Bumps and Wrinkles

After making the preceding adjustments and reducing the amplitude of the bumps a bit, you can start removing the wrinkles and bumps to a greater degree. Again start with the Vertical Amplifier end and work through the line to the crt.

Advance the sweep rate to .5 μSEC/CM and adjust C553, C563, L553 and L563 again to reduce the wrinkles in the vicinity of the termination bump. Do not try to achieve a perfectly straight line across the top of the display at this time; just reduce the amplitude of the bumps by about one-half. Then advance to the first group of capacitors in the Delay Line (about four or five) and adjust them for a reasonably smooth line over that portion of the display they affect. Keep in mind that each capacitor will require only a slight adjustment, and that it is the combined effect of a group of capacitors with which you must be concerned. As you advance along the line, from one group of capacitors to the next, reduce the sweep rate from time to time to check the level. It is just as important to maintain the level of the display as it is to obtain a wrinkle-free display.

After traversing the entire length of the line, advance the sweep rate to .2 μSEC/CM and repeat the process. Be extremely careful in your adjustments at this time. Any capacitors that require adjustment will need only a slight touch...any over-adjustment might nullify all of your efforts up to this point. From time to time switch back to a sweep rate of 20 μSEC/CM to check the level.

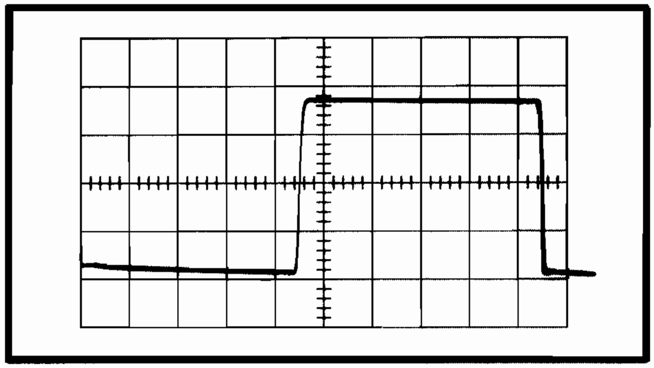


Fig. 6-8. The level, wrinkle-free display indicates proper adjustment of the Delay Line; the rounded corner is due to the fact that the variable inductors in the Vertical Amplifier and at the crt end of the line have not as yet been adjusted from their preset position.

Final Compensation

Upon completing this portion of the adjustment, the display should appear similar to Fig. 6-8. That is, the display should be level and free from aberrations, with a pronounced rolloff at the leading corner. Then adjust L506 and L523 in the Vertical Amplifier and L955 and L956 at the crt end of the line, being careful to adjust any two that make up one pair the same amount. Conitnue adjusting each pair of inductors, maintaining balance, until the corner begins to square up. This process will introduce some new wrinkles in the display, but these can easily be removed by adjusting the first few capacitors of the Delay Line at the crt end of the line. When the Delay Line and Vertical Amplifier are in proper adjustment, the display should appear similar to Fig. 6-7(a).

METHOD USING THE TYPE 107 SQUARE-WAVE GENERATOR AND TYPE K PLUG-IN UNIT

Install the Type K Unit (or other type preamplifier) in the Type 531A. Connect a B52-R Terminating Resistor to the INPUT connector of the plug-in unit and connect a 52-ohm coaxial cable between the Terminating Resistor and the OUTPUT connector of the Type 107. Set the front-panel controls as follows:

Type 531A

STABILITY	full right
TRIGGERING LEVEL	full right

TRIGGER SLOPE	—INT.
TRIGGERING MODE	AC LF REJECT
TIME/CM	.2 μSEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	NORMAL

Type K Unit*

AC/DC	AC
VOLTS/CM	.05
VARIABLE	CALIBRATED

* Set the VOLTS/CM control to the most sensitive DC range for the plug-in unit being used. It is very important to bypass the effect of the attenuators in all pulg-in units, and the effect of any ac-coupled preamplifier that some plug-in units employ. Again, make sure that the VOLTS/CM is set to the most sensitive DC range, and that the VARIABLE control is in the CALIBRATED position.

Type 107

APPROXIMATE FREQUENCY	White dot at 9 o'clock
APPROXIMATE AMPLITUDE	Adjust for 3 centimeters deflection

Adjust the INTENSITY and VERTICAL POSITION controls so that two free-running traces are visible on the crt. Then turn the STABILITY control to PRESET and adjust the TRIGGERING LEVEL control to obtain a stable display. Adjust the HORIZONTAL POSITION control so that the entire positive half-cycle is visible on the crt, and adjust the FOCUS and ASTIGMATISM controls for the sharpest display. The display should then appear similar to Fig. 6-9. From this point the adjustment procedure is identical to that presented for using the Type P Unit.

(22) Check Bandwidth of Vertical Deflection System

Install a properly calibrated Type K Unit in the Type 531A and connect the output cable from the Constant-Amplitude Signal Generator to the INPUT connector of the Type K Unit. Set up the front-panel controls as follows:

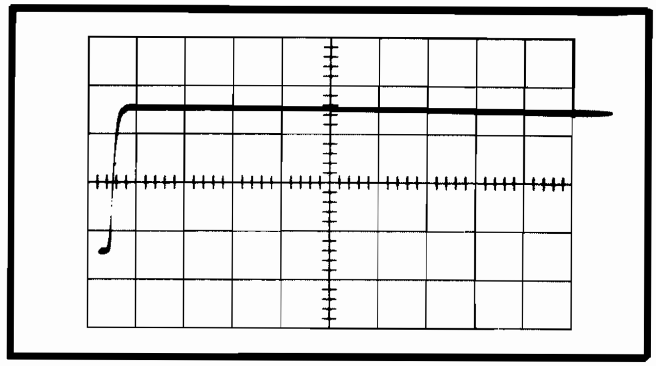


Fig. 6-9. The Type 107 waveform displayd on a properly adjusted Type 531A/K-Unit combination; sweep rate: 0.2 μsec/cm.

STABILITY	full right
TRIGGERING LEVEL	any position
TRIGGER SLOPE	INT (+ or —)
TRIGGER MODE	AC LF REJECT, AC or DC
TIME/CM	1 MILLISEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	NORMAL

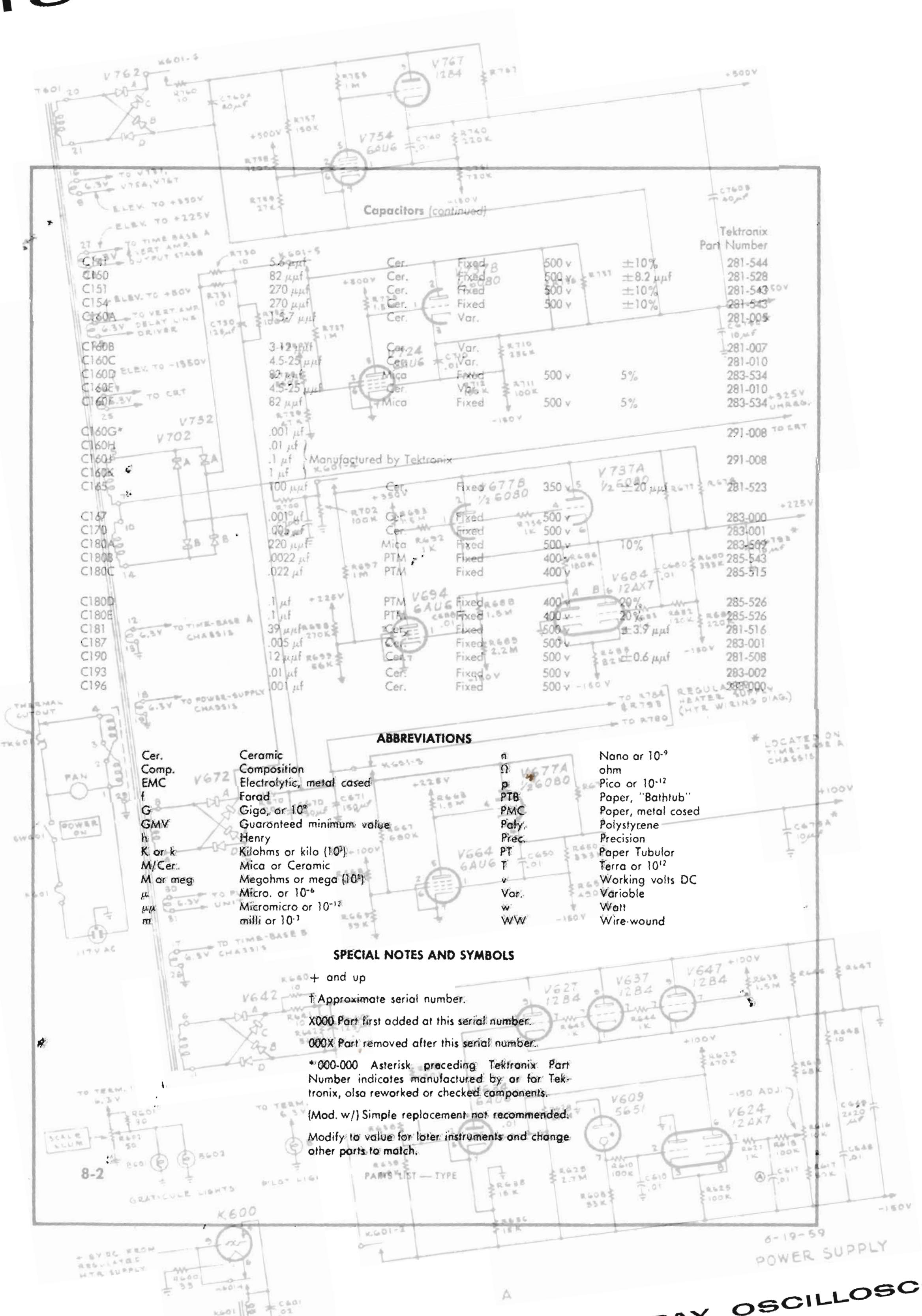
Type K Unit

AC/DC	DC
VOLTS/CM	.05
VARIABLE	CALIBRATED

Set the frequency controls on the Signal Generator for an output frequency of 500 kc, and adjust the amplitude controls for a vertical deflection of exactly 4 centimeters. Position the display on the crt (with the VERTICAL DEFLECTION control) so that the deflection extends exactly from the top graticule mark to the bottom graticule mark.

Then increase the output frequency of the Signal Generator to 15 mc (make sure the VOLTS/CM and VARIABLE controls are set to .05 and CALIBRATED, respectively); the deflection should be at least 2.8 centimeters at 15 mc. If not, the Vertical Amplifier and the Delay Line (and possibly the Type K Unit) are in need of further adjustment. For plug-in units other than the K Unit the bandpass will be different; see Table 1 in the Characteristics section of this manual for the bandpass characteristics of other plug-in units in conjuction with the Type 531A.

PARTS LIST *and* DIAGRAMS



Capacitors *(continued)*

						Tektronix Part Number
C141	5.6 μμf	Cer.	Fixed	500 v	±10%	281-544
C150	82 μμf	Cer.	Fixed	500 v	±8.2 μμf	281-528
C151	270 μμf	Cer.	Fixed	500 v	±10%	281-543
C154	270 μμf	Cer.	Fixed	500 v	±10%	281-543
C160A	1.5-7 μμf	Cer.	Var.			281-005
C160B	3-12 μμf	Cer.	Var.			281-007
C160C	4.5-25 μμf	Cer.	Var.			281-010
C160D	82 μμf	Mica	Fixed	500 v	5%	283-534
C160E	4.5-25 μμf	Cer.	Var.			281-010
C160F	82 μμf	Mica	Fixed	500 v	5%	283-534
C160G*	.001 μf					291-008
C160H	.01 μf					
C160J	.1 μf	Manufactured by Tektronix				291-008
C160K	1 μf					
C165	100 μμf	Cer.	Fixed	350 v	±20 μμf	281-523
C167	.001 μf	Cer.	Fixed	500 v		283-000
C170	.005 μf	Cer.	Fixed	500 v		283-001
C180A	220 μμf	Mica	Fixed	500 v	10%	283-509
C180B	.0022 μf	PTM	Fixed	400 v		285-543
C180C	.022 μf	PTM	Fixed	400 v		285-515
C180D	.1 μf	PTM	Fixed	400 v	20%	285-526
C180E	.1 μf	PTM	Fixed	400 v	20%	285-526
C181	39 μμf	Cer.	Fixed	500 v	±3.9 μμf	281-516
C187	.005 μf	Cer.	Fixed	500 v		283-001
C190	12 μμf	Cer.	Fixed	500 v	±0.6 μμf	281-508
C193	.01 μf	Cer.	Fixed	500 v		283-002
C196	.001 μf	Cer.	Fixed	500 v		283-000

ABBREVIATIONS

Cer.	Ceramic	n	Nano or 10^{-9}
Comp.	Composition	Ω	ohm
EMC	Electrolytic, metal cased	p	Pico or 10^{-12}
f	Farad	PTB	Paper, "Bathtub"
G	Giga, or 10^{9}	PMC	Paper, metal cased
GMV	Guaranteed minimum value	Poly.	Polystyrene
h	Henry	Prec.	Precision
K or k	Kilohms or kilo (10^{3})	PT	Paper Tubular
M/Cer.	Mica or Ceramic	T	Terra or 10^{12}
M or meg	Megohms or mega (10^{6})	v	Working volts DC
μ	Micro. or 10^{-6}	Var.	Variable
μμ	Micromicro or 10^{-12}	w	Watt
m	milli or 10^{-3}	WW	Wire-wound

SPECIAL NOTES AND SYMBOLS

+ and up

† Approximate serial number.

X000 Part first added at this serial number.

000X Part removed after this serial number.

*000-000 Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, also reworked or checked components.

(Mod. w/) Simple replacement not recommended.

Modify to value for later instruments and change other parts to match.

8-2 PARTS LIST — TYPE

MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

HOW TO ORDER PARTS

Replacement parts are available from or through your local Tektronix Field Office.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Field Office will contact you concerning any change in part number.

PARTS LIST

ABBREVIATIONS

Cer.	Ceramic	m	milli or 10^{-3}
Comp.	Composition	Ω	ohm
EMC	Electrolytic, metal cased	PTB	Paper, "Bathtub"
f	Farad	PMC	Paper, metal cased
GMV	Guaranteed minimum value	Poly.	Polystyrene
h	Henry	Prec.	Precision
k	Kilohm or 10^3 ohms	PT	Paper Tubular
M/Cer.	Mica or Ceramic	v	Working volts DC
meg	Megohm or 10^6 ohms	Var.	Variable
μ	Micro. or 10^{-6}	w	Watt
μμ	Micromicro or 10^{-12}	WW	Wire-wound

Special Notes and Symbols

+ and up

† Approximate serial number

X000 Part first added at this serial number.

000X Part removed after this serial number.

(Mod. w/) Simple replacement not recommended. Modify to value for later instruments and change other parts to match.

Bulbs

			Tektronix Part Number
B160W	20001-26519	Type NE-23 Neon Bulb	Use 150-027
B160W	26520-up	Type NE-2V Neon Bulb	150-0030-00
B167		Type NE-23 Neon Bulb	Use 150-027
B171		Type NE-23 Neon Bulb	Use 150-027
B347	20001-26519	Type NE-23 Neon Bulb	Use 150-027
B347	26520-up	Type NE-2V Neon Bulb	150-0030-00
B386		Type NE-23 Neon Bulb	Use 150-027
B397	20001-26519	Type NE-23 Neon Bulb	Use 150-027
B397	26520-up	Type NE-2V Neon Bulb	150-0030-00
B398	20001-26519	Type NE-23 Neon Bulb	Use 150-027
B398	26520-up	Type NE-2V Neon Bulb	150-0030-00
B536	20001-26519	Type NE-23 Neon Bulb	Use 150-027
B536	26520-up	Type NE-2V Neon Bulb	150-0030-00
B546	20001-26519	Type NE-23 Neon Bulb	Use 150-027
B546	26520-up	Type NE-2V Neon Bulb	150-0030-00
B601		Incandescent, #47	150-001
B602		Incandescent, #47	150-001
B603		Incandescent, #47	150-001

Capacitors

C1		4.7 μμf	Cer.	Fixed	500 v	±1 μμf	281-501
C2	X25080-up	.02 μf	Cer.	Fixed	600 v		283-006
C10	20001-21129	.0047 μf	PTM	Fixed	400 v		Use 285-543
C10	21130-up	.0022 μf	PTM	Fixed	400 v		285-543
C11		100 μμf	Cer.	Fixed	350 v	±20 μμf	281-523
C15		.001 μf	Cer.	Fixed	500 v		283-000
C20		.001 μf	Cer.	Fixed	500 v		283-000
C24		47 μμf	Cer.	Fixed	500 v	±9.4 μμf	281-518
C31		.01 μf	PTM	Fixed	400 v		285-510
C37		22 μμf	Cer.	Fixed	500 v	±4.4 μμf	281-510
C47		.005 μf	Cer.	Fixed	500 v		283-001
C116		.001 μf	Cer.	Fixed	500 v		283-000
C131		27 μμf	Cer.	Fixed	500 v	±5.4 μμf	281-513
C134		8 μμf	Cer.	Fixed	500 v	±0.5 μμf	281-503
C138		.005 μf	Cer.	Fixed	500 v		283-001
C141		8 μμf	Cer.	Fixed	500 v	±0.5 μμf	281-503

Capacitors *(continued)*

							Tektronix Part Number
C150		82 $\mu\mu$f	Cer.	Fixed	500 v	$\pm$8.2 $\mu\mu$f	281-528
C151		.005 μf	Cer.	Fixed	500 v		283-001
C157		12 $\mu\mu$f	Cer.	Fixed	500 v	$\pm$1.2 $\mu\mu$f	281-506
C160A		3-12 $\mu\mu$f	Cer.	Var.			281-007
C160B		82 $\mu\mu$f	Mica	Fixed		5%	283-534
C160C		4.5-25 $\mu\mu$f	Cer.	Var.			281-010
C160D		82 $\mu\mu$f	Mica	Fixed		5%	283-534
C160E		4.5-25 $\mu\mu$f	Cer.	Var.			281-010
C160F		.001 μf	Mylar			$\pm$½%	*291-008
C160G		.01 μf	Mylar Timing Series				
C160H		.1 μf	Mylar Timing Series			$\pm$½%	*291-007
C160J		1 μf	Mylar Timing Series				
C160K	X23190-up	270 $\mu\mu$f	Cer.	Fixed	500 v		281-543
C165		470 $\mu\mu$f	Cer.	Fixed	500 v		281-525
C167		.001 μf	Cer.	Fixed	500 v		283-000
C180A		220 $\mu\mu$f	Mica	Fixed		10%	283-536
C180B		.0022 μf	PTM	Fixed	400 v		285-543
C180C		.022 μf	PTM	Fixed	400 v		285-515
C180D		.1 μf	PTM	Fixed	400 v		285-526
C180E		.1 μf	PTM	Fixed			285-526
C181	20001-20059	39 $\mu\mu$f	Cer.	Fixed	500 v	$\pm$3.9 $\mu\mu$f	281-517
C181	20060-up	27 $\mu\mu$f	Cer.	Fixed	500 v	$\pm$1.35 $\mu\mu$f	281-515
C187		.005 μf	Cer.	Fixed	500 v		283-001
C190	20001-20199	18 $\mu\mu$f	Cer.	Fixed	500 v	$\pm$10%	Use 281-509
	20200-up	15 $\mu\mu$f	Cer.	Fixed	500 v	$\pm$10%	281-509
C193		.005 μf	Cer.	Fixed	500 v		283-001
C196		.001 μf	Cer.	Fixed	500 v		283-000
C301C		7-45 $\mu\mu$f	Cer.	Var.			281-012
C301E		330 $\mu\mu$f	Cer.	Fixed	500 v	$\pm$10%	281-546
C330		4.5-25 $\mu\mu$f	Cer.	Var.	500 v		281-010
C336		.005 μf	Cer.	Fixed	500 v		283-001
C340		4.7 $\mu\mu$f	Cer.	Fixed	500 v	$\pm$1 $\mu\mu$f	281-501
C347	X20520-up	.001 μf	Cer.	Fixed	500 v		283-000
C348		3-12 $\mu\mu$f	Cer.	Var.	500 v		281-007
C355		1.5 $\mu\mu$f	Cer.	Fixed	500 v	$\pm$0.5 $\mu\mu$f	281-526
C356		.005 μf	Cer.	Fixed	500 v		283-001
C364		3-12 $\mu\mu$f	Cer.	Var.	500 v		281-036
C375		9-180 $\mu\mu$f	Mica	Var.	500 v		281-023
C380		6.25 μf	EMT	Fixed	300 v		290-000
C384		3-12 $\mu\mu$f	Cer.	Var.	500 v		281-036
C390		4.7 $\mu\mu$f	Cer.	Fixed	500 v	$\pm$1 $\mu\mu$f	281-501
C393		.047 μf	PTM	Fixed	400 v		285-519
C396	X20620-up	.005 μf	Cer.	Fixed	500 v		283-001
C505		.005 μf	Cer.	Fixed	500 v		283-001
C507A,B		2 x 10 μf	EMC	Fixed	250 v		Use 290-075
C510		.005 μf	Cer.	Fixed	500 v		283-001
C517		.001 μf	Cer.	Fixed	500 v		283-000
C528		.005 μf	Cer.	Fixed	500 v		283-001
C537		.005 μf	Cer.	Fixed	500 v		283-001
C543		.005 μf	Cer.	Fixed	500 v		283-001
C547		.005 μf	Cer.	Fixed	500 v		283-001
C550		.005 μf	Cer.	Fixed	500 v		283-001
C553		1.5-7 $\mu\mu$f	Cer.	Var.	500 v		281-034
C556		.001 μf	Cer.	Fixed	500 v		283-000
C563		5-25 $\mu\mu$f	Cer.	Var.	500 v		281-011
C566		.001 μf	Cer.	Fixed	500 v		283-000

							Tektronix Part Number
C582		.005 μf	Cer.	Fixed	500 v		283-001
C587		8 μμf	Cer.	Fixed	500 v		281-503
C588		39 μμf	Cer.	Fixed	500 v		281-516
C596		.005 μf	Cer.	Fixed	500 v		283-001
C599		.022 μf	Cer.	Fixed	600 V	10%	285-517
C601	20001-22085	.02 μf	Discap	Fixed	150 v		283-004
C601	22086-up	.1 μf	Discap	Fixed	500 v		283-008
C603		2 x 40 μf	EMC	Fixed	250 v		Use 290-012
C605A		40 μf					
C605B		20 μf	EMC	Fixed	475 v		Use 290-062
C605C		10 μf					
C610		.01 μf	PTM	Fixed	400 v		285-510
C617		.01 μf	PTM	Fixed	400 v		285-510
C628		.01 μf	PTM	Fixed	400 v		285-510
C640		125 μf	EMC	Fixed	350 v		Use 290-016
C648		.01 μf	Cer.	Fixed	500 v		283-002
C649		2 x 40 μf	EMC	Fixed	250 v		Use 290-012
C650		.01 μf	PTM	Fixed	400 v		285-510
C670		150 μf	EMC	Fixed	250 v		Use 290-019
C671		150 μf	EMC	Fixed	250 v		Use 290-019
C679A,B,C		3 x 10 μf	EMC	Fixed	450 v		Use 290-005
C680		.01 μf	PTM	Fixed	400 v		285-510
C688		.01 μf	PTM	Fixed	400 v		285-510
C700		125 μf	EMC	Fixed	450 v		Use 290-017
C710	20001-20319	.01 μf	PTM	Fixed	400 v		Use 285-511
C710	20320-up	.01 μf	PTM	Fixed	600 v		285-511
C730		125 μf	EMC	Fixed	350 v		Use 290-016
C740		.01 μf	PTM	Fixed	400 v		285-510
C760A,B		2 x 40 μf	EMC	Fixed	450 v		Use 290-013
C780		.005 μf	Cer.	Fixed	500 v		283-001
C785		.01 μf	PTM	Fixed	500 v		283-002
C801		.047 μf	PTM	Fixed	400 v		285-519
C802		2 x 20 μf	EMC	Fixed	450 v		Use 290-010
C803		.001 μf	PTM	Fixed	600 v		285-501
C806		.01 μf	PTM	Fixed	400 v		285-510
C808		.001 μf	PTM	Fixed	600 v		285-501
C819	X22290-up	.1 μf	Cer.	Fixed	200 v		Use 283-057
C820	20001-21131	.0068 μf	PTM	Fixed	3000 v		285-508
C820	21132-up	.01 μf	Cer.	Fixed	2000 v		283-011
C821	20001-20649	.015 μf	PTM	Fixed	3000 v		285-513
C821	20650-up	.01 μf	Cer.	Fixed	2000 v		283-011
C822	X20060-up	470 μμf	Cer.	Fixed			281-525
C827	20001-20649	.015 μf	PTM	Fixed	3000 v		285-513
C827	20650-up	.01 μf	Cer.	Fixed	2000 v		283-011
C828	X20650-up	.01 μf	Cer.	Fixed	2000 v		283-011
C829	X22290-up	.001 μf	Cer.	Fixed	500 v		283-000
C831	20001-21131	.0068 μf	PTM	Fixed	3000 v		285-508
C831	21132-up	.01 μf	Cer.	Fixed	2000 v		283-011
C832		.005 μf	Cer.	Fixed	4000 v		Use 283-034
C833	20001-20599	470 μμf	PTM	Fixed	10,000 v		Use 281-556
C833	20600-up	500 μμf	Cer.	Fixed	10,000 v		281-556
C834	20001-20599	470 μμf	PTM	Fixed	10,000 v		Use 281-556
C834	20600-up	500 μμf	Cer.	Fixed	10,000 v		281-556

Capacitors *(continued)*

							Tektronix Part Number
C836	20001-20599	470 μμf	PTM	Fixed	10,000 v		Use 281-556
C836	20600-up	500 μμf	Cer.	Fixed	10,000 v		281-556
C841		.02 μf	Cer.	Fixed	600 v		Use 283-006
C842	20001-21131	.0068 μf	PTM	Fixed	3000 v		285-508
C842	21132-up	.01 μf	Cer.	Fixed	2000 v		283-011
C845	20001-20649	.015 μf	PTM	Fixed	3000 v		285-513
C845	20650-up	.01 μf	Cer.	Fixed	2000 v		283-011
C848	20001-20649	.015 μf	PTM	Fixed	3000 v		285-513
C848	20650-up	.01 μf	Cer.	Fixed	2000 v		283-011
C871		330 μμf	Mica.	Fixed	500 v	10%	283-518
C874		330 μμf	Mica.	Fixed	500 v	10%	283-518
C885		27 μμf	Cer.	Fixed	500 v	±5.4 μμf	281-513
C897		.001 μf	Cer.	Fixed	500 v		283-000
C903		.7-3 μμf	Tub.	Var.			281-037
C904		.7-3 μμf	Tub.	Var.			281-037
C905		.7-3 μμf	Tub.	Var.			281-037
C906		.7-3 μμf	Tub.	Var.			281-037
C907		.7-3 μμf	Tub.	Var.			281-037
C908		.7-3 μμf	Tub.	Var.			281-037
C909		.7-3 μμf	Tub.	Var.			281-037
C910		.7-3 μμf	Tub.	Var.			281-037
C911		.7-3 μμf	Tub.	Var.			281-037
C912		.7-3 μμf	Tub.	Var.			281-037
C913		.7-3 μμf	Tub.	Var.			281-037
C914		.7-3 μμf	Tub.	Var.			281-037
C915		.7-3 μμf	Tub.	Var.			281-037
C916		.7-3 μμf	Tub.	Var.			281-037
C917		.7-3 μμf	Tub.	Var.			281-037
C918		.7-3 μμf	Tub.	Var.			281-037
C919		.7-3 μμf	Tub.	Var.			281-037
C920		.7-3 μμf	Tub.	Var.			281-037
C925 †		10 meg	½ w	Fixed	Comp.	10%	302-106
C926 †		10 meg	½ w	Fixed	Comp.	10%	302-106
C930		.7-3 μμf	Tub.	Var.			281-037
C931		.7-3 μμf	Tub.	Var.			281-037
C932		.7-3 μμf	Tub.	Var.			281-037
C933		.7-3 μμf	Tub.	Var.			281-037
C934		.7-3 μμf	Tub.	Var.			281-037
C935		.7-3 μμf	Tub.	Var.			281-037
C936		.7-3 μμf	Tub.	Var.			281-037
C937		.7-3 μμf	Tub.	Var.			281-037
C938		.7-3 μμf	Tub.	Var.			281-037
C939		.7-3 μμf	Tub.	Var.			281-037
C940		.7-3 μμf	Tub.	Var.			281-037

Diodes

Even though the diodes may be different in physical size they are direct electrical replacements for the diodes in your instrument.

D131	X20255-up	T12G	152-008
D642A,B,C,D		Silicon Diodes	152-047
D672A,B,C,D		Silicon Diodes	152-047
D679	X22350-up	Silicon Diodes	152-047
D702A,B		Silicon Diodes	152-047
D732A,B		Silicon Diodes	152-047
D762A,B,C,D		Silicon Diodes	152-047

† C925 and C926 used in delay line for their capacitive properties.

Fuses

		Tektronix Part Number
F601	6 amp, Fast-Blo 3AG for 117 v operation, 60 cycle	159-013
F601	3 amp, Fast-Blo 3AG for 234 v operation, 60 cycle	159-015
F601	6.25 amp, Slo-Blo 3AG for 117 v operation, 50 cycle	159-011
F601	3 amp, Slo-Blo 3AG for 234 v operation, 50 cycle	159-005

Inductors

LR149		1 µh	Fixed		*108-058
L506	20001-22289	15-34 µh	Var.	core 276-511	*114-121
L506	22290-22439	10-21 µh	Var.	core 276-511	*114-100
L506	22440-up	15-34 µh	Var.	core 276-511	*114-121
L523	20001-22289	15-34 µh	Var.	core 276-511	*114-121
L523	22290-22439	10-21 µh	Var.	core 276-511	*114-100
L523	22440-up	15-34 µh	Var.	core 276-511	*114-121
L526		1.4 µh	Fixed		*108-095
L541		1.4 µh	Fixed		*108-095
L551		1.2 µh	Fixed		*108-056
L553		11-28 µh	Var.	core 276-511	*114-102
L561		1.2 µh	Fixed		*108-056
L563		11-28 µh	Var.	core 276-511	*114-102
L582		18 µh	Fixed		*108-129
L905		Delay Line 18 sec.	Fixed		use *108-178
L906		Delay Line 18 sec.	Fixed		use *108-178
L925		1.2 µh	Fixed		*108-056
L926		1.2 µh	Fixed		*108-056
L935		Delay Line 11 sec.	Fixed		use *108-179
L936		Delay Line 11 sec.	Fixed		use *108-179
L955		3.6-7.2 µh	Var.	core 276-506	*114-105
L956		3.6-7.2 µh	Var.	core 276-506	*114-105

Resistors

R1		1 meg	½ w	Fixed	Comp.		301-105
R2		390 k	½ w	Fixed	Comp.	5%	301-394
R3		50 k	2 w	Var.	Comp.	20%	311-023
R4		100 k	½ w	Fixed	Comp.	10%	302-104
R5	X25080-up	10 meg	½ w	Fixed	Comp.		302-106
R12		1 meg	½ w	Fixed	Comp.	10%	302-105
R13		100 k	½ w	Fixed	Comp.	10%	302-104
R15		470 k	½ w	Fixed	Comp.	10%	302-474
R17*		2 x 100 k	½ w	Var.	Comp.	20%	311-096
R18		22 k	½ w	Fixed	Comp.	10%	302-223
R19		470 k	½ w	Fixed	Comp.	10%	302-474
R20		56 k	½ w	Fixed	Comp.	10%	302-563
R22		47 Ω	½ w	Fixed	Comp.	10%	302-470
R23		47 Ω	½ w	Fixed	Comp.	10%	302-470
R24		4.7 k	1 w	Fixed	Comp.	10%	304-472
R25		4.7 k	1 w	Fixed	Comp.	10%	304-472
R28		33 k	2 w	Fixed	Comp.	10%	306-333
R29		39 k	2 w	Fixed	Comp.	10%	306-393
R31		47 k	½ w	Fixed	Comp.	10%	302-473
R32		47 k	½ w	Fixed	Comp.	10%	302-473
R33		47 Ω	½ w	Fixed	Comp.	10%	302-470

*Concentric with R110 & SW110. Furnished as a unit.

							Tektronix Part Number
R34		680 Ω	½ w	Fixed	Comp.	10%	302-681
R35		1.5 k	½ w	Fixed	Comp.	10%	302-152
R37		100 k	½ w	Fixed	Comp.	10%	302-104
R38		120 k	½ w	Fixed	Comp.	10%	302-124
R39		100 k	2 w	Var.	Comp.	20%	311-026
R40		2.7 meg	½ w	Fixed	Comp.	10%	302-275
R41		47 Ω	½ w	Fixed	Comp.	10%	302-470
R43		1.5 k	½ w	Fixed	Comp.	10%	302-152
R44		1 meg	½ w	Fixed	Comp.	10%	302-105
R46		18 k	1 w	Fixed	Comp.	10%	304-183
R47		500 Ω	2 w	Var.	Comp.	10%	311-005
R48		18 k	1 w	Fixed	Comp.	10%	304-183
R110*		2 x 100 k	½ w	Var.	Comp.	20%	311-096
R111	20001-21439	100 k	0.2 w	Var.	Comp.	20%	Use 311-219
R111	21440-up	200 k	0.2 w	Var.	Comp.	20%	311-219
R114		470 k	½ w	Fixed	Comp.	5%	301-474
R115		100 k	½ w	Fixed	Comp.	5%	301-104
R116		180 k	½ w	Fixed	Comp.	5%	301-184
R121		47 Ω	½ w	Fixed	Comp.	10%	302-470
R130		22 k	2 w	Fixed	Comp.	10%	306-223
R131		1 k	½ w	Fixed	Comp.	10%	302-102
R132		47 Ω	½ w	Fixed	Comp.	10%	302-470
R134		6 k/3 k	3 w		Prec		*310-555
R137		47 Ω	½ w	Fixed	Comp.	10%	302-470
R138		47 Ω	½ w	Fixed	Comp.	10%	302-470
R141		33 k	1 w	Fixed	Prec.	1%	310-070
R143		30 k	1 w	Fixed	Prec.	1%	310-072
R144		8 k	5 w	Fixed	WW	5%	308-053
R146		47 Ω	½ w	Fixed	Comp.	10%	302-470
R147		1 k	½ w	Fixed	Comp.	10%	302-102
R148		47 k	½ w	Fixed	Comp.	10%	302-473
R150		270 Ω	½ w	Fixed	Comp.	10%	302-271
R151		68 k	½ w	Fixed	Comp.	5%	301-683
R152		1 meg	½ w	Fixed	Comp.	5%	301-105
R153		10 k	½ w	Fixed	Comp.	10%	302-103
R155		1.8 meg	½ w	Fixed	Comp.	10%	302-185
R156		1 meg	½ w	Fixed	Comp.	10%	302-105
R157		470 k	½ w	Fixed	Comp.	10%	302-474
R158		1 k	½ w	Fixed	Comp.	10%	302-102
R159		3.3 k	2 w	Fixed	Comp.	10%	306-332
R160A		100 k	½ w	Fixed	Prec.	1%	309-045
R160 B		200 k	½ w	Fixed	Prec.	1%	309-051
R160C		500 k	½ w	Fixed	Prec.	1%	309-003
R160D		1 meg	½ w	Fixed	Prec.	1%	309-014
R160E		2 meg	½ w	Fixed	Prec.	1%	309-023
R160F		5 meg	½ w	Fixed	Prec.	1%	309-087
R160G		10 meg	1 w	Fixed	Prec.	1%	310-107
R160H		10 meg	1 w	Fixed	Prec.	1%	310-107
R160J		30 meg	2 w	Fixed	Prec.	1%	310-505
R160V	X20860-up	1 meg	½ w	Fixed	Comp.	10%	302-105
R160W		100 k	½ w	Fixed	Comp.	10%	302-104
R160X		10 k	½ w	Fixed	Comp.	10%	302-103
R160Y †		20 k	2 w	Var.	WW	10%	311-108
R164		22 k	2 w	Fixed	Comp.	10%	306-223
R165		22 k	2 w	Fixed	Comp.	10%	306-223
R166		22 k	2 w	Fixed	Comp.	10%	306-223

*Concentric with R17 and ganged with SW110. Furnished as a unit.

† R160Y is concentric with SW160 and SW160Y.

							Tektronix Part Number
R167		1.5 meg	½ w	Fixed	Comp.	10%	302-155
R168		47 k	½ w	Fixed	Comp.	10%	302-473
R171		47 Ω	½ w	Fixed	Comp.	10%	302-470
R172		47 Ω	½ w	Fixed	Comp.	10%	302-470
R173		470 Ω	½ w	Fixed	Comp.	10%	302-471
R174		8 k	5 w	Fixed	WW	5%	308-053
R176		2 k	2 w	Var.	Comp.		311-008
R178		4 k	5 w	Fixed	WW	5%	308-051
R180A		470 k	½ w	Fixed	Comp.	10%	302-474
R180B		4.7 meg	½ w	Fixed	Comp.	10%	302-475
R181		4.7 meg	½ w	Fixed	Comp.	10%	302-475
R183		47 Ω	½ w	Fixed	Comp.	10%	302-470
R186		47 Ω	½ w	Fixed	Comp.	10%	302-470
R187		47 Ω	½ w	Fixed	Comp.	10%	302-470
R189		56 k	2 w	Fixed	Comp.	10%	306-563
R190		47 k	½ w	Fixed	Comp.	10%	302-473
R191	20001-20859	120 k	½ w	Fixed	Comp.	10%	Use 301-114
R191	20860-up	110 k	½ w	Fixed	Comp.	5%	301-114
R192		47 Ω	½ w	Fixed	Comp.	10%	302-470
R193		47 Ω	½ w	Fixed	Comp.	10%	302-470
R194		4.7 k	1 w	Fixed	Comp.	10%	304-472
R196		100 k	½ w	Fixed	Comp.	10%	302-104
R199		100 k	1 w	Fixed	Comp.	10%	304-104
R300		47 Ω	½ w	Fixed	Comp.	10%	302-470
R301C		900 k	½ w	Fixed	Prec.	1%	309-111
R301E		111 k	½ w	Fixed	Prec.	1%	309-046
R303		1 meg	½ w	Fixed	Prec.	1%	309-014
R304		1 k	½ w	Fixed	Comp.	10%	302-102
R306		47 k	1 w	Fixed	Comp.	10%	304-473
R307		50 k	2 w	Var.	Comp.	20%	311-023
R308		33 k	1 w	Fixed	Comp.	10%	304-333
R311		100 Ω	½ w	Fixed	Comp.	10%	302-101
R313		33 k	2 w	Fixed	Comp.	10%	Use 306-0333-00
R314		15 k	2 w	Var.	Comp.	10%	Use 311-0571-00
R315		33 k	2 w	Fixed	Comp.	10%	Use 306-0333-00
R317		100 Ω	½ w	Fixed	Comp.	10%	302-101
R318		27 k	2 w	Fixed	Comp.	10%	Use 306-0273-00
R330		1.5 meg	½ w	Fixed	Prec.	1%	309-017
R332		3.5 meg	½ w	Fixed	Prec.	1%	309-086
R333*		100 k	2 w	Var.	Comp.	20%	311-149
R336		12.1 meg	½ w	Fixed	Prec.	1%	309-268
R338*		200 k	2 w	Var.	Comp.	20%	311-149
R340		2.2 k	½ w	Fixed	Comp.	10%	302-222
R341		100 Ω	½ w	Fixed	Comp.	10%	302-101
R345		100 k	1 w	Fixed	Comp.	10%	304-104
R347		100 k	½ w	Fixed	Comp.	10%	302-104
R348		50 k	2 w	Var.	Comp.	±20%	311-125
R349	20001-20799	111 k	½ w	Fixed	Prec.	1%	Use 309-091
R349	20800-up	120 k	½ w	Fixed	Prec.	1%	309-091
R351		100 Ω	½ w	Fixed	Comp.	10%	302-101
R353		100 k	1 w	Fixed	Comp.	10%	304-104

*R333 and R338 are concentric. Furnished as a unit.

Resistors *(continued)*

							Tektronix Part Number
R355		400 k	1 w	Fixed	Prec.	1%	310-094
R356		400 k	1 w	Fixed	Prec.	1%	310-094
R357	20001-22229	22 k	½ w	Fixed	Comp.	10%	Use 304-223
R357	22230-up	22 k	1 w	Fixed	Comp.	10%	304-223
R358	20001-20859	10 k	2 w	Var.	Comp.		Use 311-018
R358	20860-up	20 k	2 w	Var.	Comp.		311-018
R361		47 Ω	½ w	Fixed	Comp.	10%	302-470
R364		6—25 k	7 w		Prec.	1%	*310-506
R366		47 Ω	½ w	Fixed	Comp.	10%	302-470
R373		2.2 k	1 w	Fixed	Comp.	10%	304-222
R375		2 k	2 w	Var.	Comp.		311-008
R376		2.2 k	1 w	Fixed	Comp.	10%	304-222
R377		6 k	5 w	Fixed	WW	5%	308-052
R380		100 Ω	½ w	Fixed	Comp.	10%	302-101
R381		47 Ω	½ w	Fixed	Comp.	10%	302-470
R384		6—30 k	7 w		Prec	1%	*310-507
R386		100 Ω	½ w	Fixed	Comp.	10%	302-101
R387		39 k	2 w	Fixed	Comp.	10%	306-393
R388		39 k	2 w	Fixed	Comp.	10%	306-393
R390		2.2 k	½ w	Fixed	Comp.	10%	302-222
R391		47 Ω	½ w	Fixed	Comp.	10%	302-470
R393		390 Ω	½ w	Fixed	Comp.	10%	302-391
R396		470 k	½ w	Fixed	Comp.	10%	302-474
R397		820 k	½ w	Fixed	Comp.	10%	302-824
R398		820 k	½ w	Fixed	Comp.	10%	302-824
R399		470 k	½ w	Fixed	Comp.	10%	302-474
R502		27 Ω	½ w	Fixed	Comp.	10%	302-270
R505		680 Ω	2 w	Fixed	Comp.	5%	305-681
R506		1.582 k	½ w	Fixed	Prec.	1%	309-029
R507		82 k	¼ w	Fixed	Comp.	10%	316-823
R510		6.8 k	1 w	Fixed	Comp.	10%	304-682
R513		4 k	5 w	Fixed	WW	5%	308-051
R514		15 k	5 w	Fixed	WW	5%	308-108
R517		470 k	½ w	Fixed	Comp.	10%	302-474
R520		27 Ω	½ w	Fixed	Comp.	10%	302-270
R523		1.582 k	½ w	Fixed	Prec.	1%	309-029
R524		82 k	¼ w	Fixed	Comp.	10%	316-823
R528		4.5 k	5 w	Fixed	WW	5%	308-092
R529		11 k	2 w	Fixed	Comp.	5%	305-113
R530		11 k	2 w	Fixed	Comp.	5%	305-113
R533	20001-22289	150 k	½ w	Fixed	Comp.	10%	302-154
R533	22290-up	100 k	½ w	Fixed	Comp.	10%	302-104
R534		330 k	½ w	Fixed	Comp.	10%	302-334
R536		330 k	½ w	Fixed	Comp.	10%	302-334
R537		1 meg	½ w	Fixed	Comp.	10%	302-105
R539		680 k	½ w	Fixed	Comp.	10%	302-684
R546		330 k	½ w	Fixed	Comp.	10%	302-334
R547		1 meg	½ w	Fixed	Comp.	10%	302-105
R550		1.2 k	1 w	Fixed	Comp.	10%	304-122
R551		47 Ω	½ w	Fixed	Comp.	10%	302-470
R553		1.3 k	6 w		Prec	1%	*310-549
R556		100 k	½ w	Fixed	Comp.	10%	302-104
R558		27 Ω	½ w	Fixed	Comp.	10%	302-270

							Tektronix Part Number
R561		47 Ω	½ w	Fixed	Comp.	10%	302-470
R563		1.3 k	6 w		Prec	1%	*310-549
R566		100 k	½ w	Fixed	Comp.	10%	302-104
R568		27 Ω	½ w	Fixed	Comp.	10%	302-270
R570		200 Ω	2 w	Var.	Comp.		311-004
R573		2.5 k	5 w	Fixed	WW	1%	308-103
R574		2.5 k	5 w	Fixed	WW	1%	308-103
R577		100 Ω	½ w	Fixed	Comp.	10%	302-101
R580		100 Ω	½ w	Fixed	Comp.	10%	302-101
R582		5.1 k	2 w	Fixed	Comp.	5%	305-512
R583		2.2 k	½ w	Fixed	Comp.	5%	301-222
R585		12 k	2 w	Fixed	Comp.	5%	305-123
R586		12 k	2 w	Fixed	Comp.	5%	305-123
R587		1.2 k	½ w	Fixed	Comp.	5%	301-122
R588		2.2 k	½ w	Fixed	Comp.	5%	301-222
R590		47 Ω	½ w	Fixed	Comp.	10%	302-470
R593		30 k	10 w	Fixed	WW	5%	308-027
R595		6.8 k	½ w	Fixed	Comp.	10%	302-682
R596		47 Ω	½ w	Fixed	Comp.	10%	302-470
R598		22 k	2 w	Fixed	Comp.	10%	306-223
R599		1 meg	½ w	Fixed	Comp.	10%	302-105
R600		12 Ω	1 w	Fixed	Comp.	10%	304-120
R601		30 Ω	3 w	Fixed	WW	5%	308-142
R602		50 Ω	2 w	Var.	WW	1%	311-055
R603		100 Ω	1 w	Fixed	Comp.	10%	304-101
R604	X22074-up	6 k	5 w	Fixed	WW	5%	308-052
R605		100 Ω	½ w	Fixed	Comp.	10%	302-101
R607		47 Ω	½ w	Fixed	Comp.	10%	302-470
R608		33 k	½ w	Fixed	Comp.	10%	302-333
R609		100 Ω	½ w	Fixed	Comp.	10%	302-101
R610		100 k	½ w	Fixed	Comp.	10%	302-104
R615		68 k	1 w	Fixed	Prec.	1%	310-054
R616		10 k	2 w	Var.	WW	20%	311-015
R617		50 k	1 w	Fixed	Prec.	1%	310-086
R618		100 k	½ w	Fixed	Comp.	10%	302-104
R621		1 k	½ w	Fixed	Comp.	10%	302-102
R623		470 k	½ w	Fixed	Comp.	10%	302-474
R625		100 k	½ w	Fixed	Comp.	10%	302-104
R628		2.7 meg	½ w	Fixed	Comp.	10%	302-275
R629		2.7 meg	½ w	Fixed	Comp.	10%	302-275
R633		1 meg	½ w	Fixed	Comp.	10%	302-105
R635		15 k	1 w	Fixed	Comp.	10%	304-153
R636		15 k	1 w	Fixed	Comp.	10%	304-153
R637		150 k	½ w	Fixed	Comp.	10%	302-154
R638		27 k	½ w	Fixed	Comp.	10%	302-273
R639		68 k	½ w	Fixed	Comp.	10%	302-683
R640		10 Ω	1 w	Fixed	Comp.	10%	304-100
R641		10 Ω	1 w	Fixed	Comp.	10%	304-100
R643		1 k	½ w	Fixed	Comp.	10%	302-102
R644		1 k	½ w	Fixed	Comp.	10%	302-102
R647		1.5 k	25 w	Fixed	WW	5%	308-040

Resistors *(continued)*

						Tektronix Part Number
R648	10 Ω	½ w	Fixed	Comp.	10%	302-100
R650	333 k	1 w	Fixed	Prec.	1%	310-056
R651	490 k	1 w	Fixed	Prec.	1%	310-057
R663	1.5 meg	½ w	Fixed	Comp.	10%	302-155
R667	680 k	½ w	Fixed	Comp.	10%	302-684
R668	47 k	½ w	Fixed	Comp.	10%	302-473
R669	39 k	½ w	Fixed	Comp.	10%	302-393
R670	10 Ω	2 w	Fixed	Comp.	10%	306-100
R675	600 Ω	10 w	Fixed	WW	5%	308-148
R676	2 k	10 w	Fixed	WW	5%	308-017
R677	2 k	10 w	Fixed	WW	5%	308-017
R678	167 Ω	5 w	Fixed	WW		308-104
R680	333 k	1 w	Fixed	Prec.	1%	310-056
R681	220 k	1 w	Fixed	Prec.	1%	310-055
R682	120 k	½ w	Fixed	Comp.	10%	302-124
R683	1 k	½ w	Fixed	Comp.	10%	302-102
R685	82 k	1 w	Fixed	Comp.	10%	304-823
R686	180 k	½ w	Fixed	Comp.	10%	302-184
R688	1.5 meg	½ w	Fixed	Comp.	10%	302-155
R689	2.2 meg	½ w	Fixed	Comp.	10%	302-225
R693	1.5 meg	½ w	Fixed	Comp.	10%	302-155
R697	1 meg	½ w	Fixed	Comp.	10%	302-105
R698	270 k	½ w	Fixed	Comp.	10%	302-274
R699	56 k	½ w	Fixed	Comp.	10%	302-563
R700	10 Ω	2 w	Fixed	Comp.	10%	306-100
R710	237 k	1 w	Fixed	Prec.	1%	Use 310-124
R711	100 k	½ w	Fixed	Prec.	1%	Use 323-385
R712	150 k	½ w	Fixed	Comp.	10%	302-154
R723	1.5 meg	½ w	Fixed	Comp.	10%	302-155
R727	1 meg	½ w	Fixed	Comp.	10%	302-105
R728	560 k	½ w	Fixed	Comp.	10%	302-564
R729	47 k	½ w	Fixed	Comp.	10%	302-473
R730	10 Ω	1 w	Fixed	Comp.	10%	304-100
R731	10 Ω	1 w	Fixed	Comp.	10%	304-100
R732	82 k	2 w	Fixed	Comp.	10%	306-823
R734	1 k	½ w	Fixed	Comp.	10%	302-102
R736	2.4 k	25 w	Fixed	WW	5%	308-041
R737	2.4 k	25 w	Fixed	WW	5%	308-041
R740	220 k	1 w	Fixed	Prec.	1%	310-055
R741	720 k	1 w	Fixed	Prec.	1%	310-059
R753	1 meg	½ w	Fixed	Comp.	10%	302-105
R757	150 k	½ w	Fixed	Comp.	10%	302-154
R758	120 k	½ w	Fixed	Comp.	10%	302-124
R759	27 k	½ w	Fixed	Comp.	10%	302-273
R760	10 Ω	½ w	Fixed	Comp.	10%	302-100
R767	4.5 k	5 w	Fixed	WW	5%	308-066
R780	100 k	½ w	Fixed	Comp.	10%	302-104
R785	100 k	½ w	Fixed	Comp.	10%	302-104
R801	1 k	½ w	Fixed	Comp.	10%	302-102
R802	390 Ω	2 w	Fixed	Comp.	10%	306-391

Resistors *(continued)*

							Tektronix Part Number
R803		56 k	2 w	Fixed	Comp.	10%	306-563
R806		100 k	½ w	Fixed	Comp.	10%	302-104
R807		1 k	½ w	Fixed	Comp.	10%	302-102
R814		470 k	½ w	Fixed	Comp.	10%	302-474
R818	X22290-up	1.8 meg	½ w	Fixed	Comp.	10%	302-185
R819	X22290-up	1.8 meg	½ w	Fixed	Comp.	10%	302-185
R820		47 k	½ w	Fixed	Comp.	10%	302-473
R822	X20060-up	33 k	½ w	Fixed	Comp.	10%	302-333
R824		4.7 meg	2 w	Fixed	Comp.	10%	306-475
R825		4.7 meg	2 w	Fixed	Comp.	10%	306-475
R826		1 meg	2 w	Var.	Comp.		311-041
R827	20001-20649	100 k	½ w	Fixed	Comp.	10%	302-104
R827	20650-up	33 k	½ w	Fixed	Comp.	10%	302-333
R828		1 meg	½ w	Fixed	Comp.	10%	302-105
R829	X22290-up	22 k	½ w	Fixed	Comp.	10%	302-223
R836		1 meg	½ w	Fixed	Comp.	10%	302-105
R840		2 meg	2 w	Var.	Comp.		311-042
R841		2.2 meg	½ w	Fixed	Comp.	10%	302-225
R842		4.7 meg	½ w	Fixed	Comp.	10%	302-475
R843		4.7 meg	½ w	Fixed	Comp.	10%	302-475
R844		4.7 meg	½ w	Fixed	Comp.	10%	302-475
R845		10 k	½ w	Fixed	Comp.	10%	302-103
R847		27 k	½ w	Fixed	Comp.	10%	302-273
R848		1 meg	½ w	Fixed	Comp.	10%	302-105
R853		2.2 meg	2 w	Fixed	Comp.	10%	306-225
R854		2.2 meg	2 w	Fixed	Comp.	10%	306-225
R856		2 meg	½ w	Var.	Comp.		311-043
R857		1 meg	2 w	Fixed	Comp.	10%	306-105
R861		100 k	2 w	Var.	Comp.	20%	311-026
R864		50 k	2 w	Var.	Comp.		311-023
R870		150 k	½ w	Fixed	Comp.	10%	302-154
R871		2.7 meg	½ w	Fixed	Comp.	10%	302-275
R872		1 k	½ w	Fixed	Comp.	10%	302-102
R874		3.9 meg	½ w	Fixed	Comp.	10%	302-395
R875		68 k	½ w	Fixed	Comp.	10%	302-683
R876		1 k	½ w	Fixed	Comp.	10%	302-102
R878		33 k	1 w	Fixed	Comp.	10%	304-333
R879		10 k	2 w	Var.	Comp.		311-016
R880		100 k	½ w	Fixed	Comp.	10%	302-104
R883		100 Ω	½ w	Fixed	Comp.	10%	302-101
R885		9.5 k	½ w	Fixed	Prec.	1%	309-121
R886		6.375 k	½ w	Fixed	Prec.	1%	309-119
R887		2.1 k	½ w	Fixed	Prec.	1%	309-117
R888		1.025 k	½ w	Fixed	Prec.	1%	309-116
R889		610 Ω	½ w	Fixed	Prec.	1%	309-113
R890		200 Ω	½ w	Fixed	Prec.	1%	309-073
R891		100 Ω	½ w	Fixed	Prec.	1%	309-112
R892		60 Ω	½ w	Fixed	Prec.	1%	309-067
R893		40 Ω	½ w	Fixed	Prec.	1%	309-066
R896		100 k	½ w	Fixed	Prec.	1%	309-045
R897		100 Ω	½ w	Fixed	Prec.	1%	309-112
R898		100 Ω	½ w	Fixed	Comp.	10%	302-101
R899		Manufactured by Tektronix					308-090

Switches

				Tektronix Part Number
				wired | unwired
SW10A		TRIGGER SLOPE	TIME BASE A	Use *262-561 260-099
SW10B		TRIGGERING MODE		
SW110		PRESET		†311-096
SW160*	20001-20059	TIME/CM		*262-222 *260-230
	20060-up	TIME/CM		*262-244 *260-230
SW160Y				311-108
SW300		HORIZONTAL DISPLAY		*262-220 *260-264
SW348		HORIZONTAL DISPLAY		*262-313 *260-265
SW601		POWER ON		260-134
SW848		CRT CATHODE SELECTOR		260-209
SW870		AMPLITUDE CALIBRATOR		262-207 260-253

Thermal Cutout

TK601		133° Thermo Switch	260-208
K600		Relay, 45 sec. Time Delay 6N045T	148-002
K601	20001-22085	Relay 4P2T 6 v	148-004
	22086-up	Relay, 2000 Ω	148-016

Transformer

T601	Power Domestic & Export Voltage Range	Use *120-140
T801	CRT Supply	*120-036

Vacuum Tubes

V24	6DJ8		154-187
V45	6DJ8	4	154-187
V133	6DJ8		154-187
V135	6DJ8		154-187
V145	12BY7		154-047
V152	6AL5	5 Selected	Use *157-0104-02
V154	6DJ8		154-187
V161	6CL6		154-031
V173	6DJ8		154-187
V183	6DJ8		154-187
V193	6DJ8	5	154-187
V303	12AU7		154-041
V314	6DJ8		154-187
V343	6DJ8		154-187
V364	6DJ8		154-187
V384	6DJ8	6	154-187
V398	6CL6		154-031
V504**	12BY7	Selected	157-053
V524**	12BY7	Selected	157-053
V533	6DJ8		154-187

*SW160 is concentric with R160Y and SW160Y.

** Furnished as a unit.

†Ganged with R110, concentric with R17. Furnished as a unit.

Vacuum Tubes *(continued)*

		Tektronix Part Number
V543	6DJ8	154-187
V554	6197	154-146
V564	6197	154-146
V584	6DJ8	154-187
V593	6DJ8	154-187
V609	5651	154-052
V624	12AX7	154-043
V627	12B4	154-044
V634	6AU6	154-022
V637	12B4	154-044
V647	12B4	154-044
V664	6AU6	154-022
V677	6080	154-056
V684	12AX7	154-043
V694	6AU6	154-022
V724	6AU6	154-022
V737	6080	154-056
V754	6AU6	154-022
V767	12B4	154-044
V800	6AU5	154-021
V814	12AU7	154-041
V822	5642	154-051
V832	5642	154-051
V842	5642	154-051
V852	5642	154-051
V859	T5330-2 CRT Standard Phosphor	*154-165
V862	5642	154-051
V875	6AU6	154-022
V885	12AU7	154-041

Type 531A
Mechanical Parts List

		Tektronix Part Number
ADAPTER, POWER CORD, 3-wire to 2-wire		103-013
ANGLE, FRAME, ALUM., $20\frac{7}{16}$, Top Left		122-019
ANGLE, FRAME, ALUM., Ext. Left Bottom	20001-20949	122-051
ANGLE, FRAME, ALUM., Ext, Left Bottom	20950-24059	122-070
ANGLE, FRAME, ALUM., Ext, Left Bottom	24060-up	122-105
ANGLE, FRAME, ALUM., Ext, Right Bottom	20001-20949	122-050
ANGLE, FRAME, ALUM., Ext, Right Bottom	20950-24059	122-071
ANGLE, FRAME, ALUM., Ext, Right Bottom	24060-up	122-104
BAR, ALUM., $\frac{3}{16} \times \frac{1}{2} \times 1\frac{3}{4}$, Retaining w/2 8-32 tapped holes		381-073
BAR, ALUM., Bottom Panel Support	20001-24059	381-107
BAR, ALUM., TRANSFORMER SUPPORT	24060-up	381-212
BAR, ALUM., EXT. CHANNEL TOP SUPPORT $20\frac{7}{16}$ w/handle		Use 381-204
BASE, ALUM., DIECAST $2\frac{3}{4} \times 3\frac{3}{16} \times \frac{9}{16}$, CRT Rotator		432-022
BOLT, SPADE STEEL 6-32 x $\frac{3}{8}$		214-012
BRACKET, ALUM., .080 x 1 x $1\frac{1}{2} \times \frac{1}{2}$ BP		406-022
BRACKET, ALUM., —150 Adj.		406-108
BRACKET, PLASTIC $\frac{13}{16} \times 1\frac{1}{2}$ Molded, Coil Mtg.		406-175
BRACKET, SP. PHOS. BRONZE .013 x $\frac{3}{4} \times 2\frac{1}{4} \times \frac{5}{8}$		406-239
BRACKET, NYLON, .160 x $\frac{3}{4} \times 1\frac{3}{8}$ Can Insul., Molded, w/.640 dia. hole		406-244
BRACKET, PHOS. BRONZE $\frac{3}{4} \times \frac{1}{2} \times 1\frac{5}{16}$, Ground Clip		406-245
BRACKET, ALUM., .080 x $4\frac{3}{8} \times 3\frac{1}{2} \times 1\frac{5}{8}$, CRT Support		406-251
BRACKET, ALUM., .063 x 1 x $2\frac{5}{16}$		406-316
BRACKET, ALUM., .080 x 2 x $5\frac{1}{2}$, WW Res. Mtg.		406-435
BRACKET, ALUM., .080 x $2\frac{1}{8} \times 8\frac{1}{2}$, w/45° angle		406-453
BRACKET, ALUM., .063 x $2\frac{7}{32} \times \frac{7}{8} \times 1\frac{9}{16}$		406-462
BRACKET, ALUM., .080 x $2\frac{1}{2}$ x 3		406-463
BRACKET, ALUM., Res. Mtg.		406-287
BRACKET, ALUM., VERT AMP SUPPORT	X24060-up	406-827
BUSHING, NYLON, "SUPERIOR" Ins. for 5-way binding post		358-036
BUSHING, BANANA JACK, BRASS $\frac{1}{4}$-32 x $\frac{13}{32}$ x .159 ID x .375 OD		358-054
CABLE, HARNESS, F & I		179-061
CABLE, HARNESS, VA		179-248
CABLE, HARNESS, POWER		179-297
CABLE, HARNESS, RECTIFIER		179-298
CABLE, HARNESS, SWEEP	SN 101-20793	179-299
CABLE, HARNESS, 110 VOLTS RECT.		179-305
CABLE, HARNESS, 110 VOLTS POWER		179-306
CABLE, HARNESS, POWER #2		179-324
CABLE, HARNESS, SWEEP	SN 20794-up	179-404
CAM, NYLON, $\frac{3}{8}$" OD x .150 hi		401-004
CAN, 500A Rect. Body		202-015
CAP, FUSE, 3 AG, raw		Use 200-582
CHASSIS, DELAY LINE Horiz. $8\frac{1}{8}$"		441-114
CHASSIS, DELAY LINE Vert. $12\frac{1}{4}$"		441-115
CHASSIS, DELAY LINE		441-176
CHASSIS, DELAY LINE Vert.		441-177
CHASSIS, VA ($\frac{3}{8}$" narrower)		441-213
CHASSIS, F & I		441-223

	Tektronix Part Number
CHASSIS, POWER	441-238
CHASSIS, SWEEP	441-243
CLAMP, CABLE, $1/8$" Plastic	343-001
CLAMP, CABLE, $3/16$" Plastic	343-002
CLAMP, CABLE, $5/16$" Plastic	343-004
CLAMP, CABLE, $1/2$" Plastic	343-006
CLAMP, CABLE, $5/16$" (half) Plastic	343-042
CLAMP, #20 Wire for Neon Bulbs	343-043
CONNECTOR, BINDING POST ADAPTOR (A510)	013-004
CONNECTOR, CHASSIS MT., Amph. 26-190-16, Scope 16-cont. female	131-018
CONNECTOR, CHASSIS MT., 1 cont. female, $1/2$" hole 20001-25079	131-081
CONNECTOR, CHASSIS MT., "D" HOLE BNC 25080-up	131-126
CONNECTOR, CABLE, 31 Anode Ass'y	131-086
CONNECTOR, CHASSIS MT., 3-wire Tekmotor Base, male	131-102
CORD, PATCH BANANA PLUG, both ends 18" Red	012-031
CORD, POWER, 16 ga. 8 ft., 3-wire, w/male & female, rnd. gnd.	161-010
COUPLING 1 lg. w/2 tapped holes	376-007
COUPLING, POT WIRE STEEL	376-014
COVER, GRATICULE	200-382
COVER, CRT ANODE & PLATE ASS'Y	200-112
EYELET, AM. BRASS .190-.183 OD tapped barrel	210-601
FAN, MOTOR	147-001
FAN, ALUM., 7" w/rubber bushing	369-007
FILTER, AIR ALUM., 10 x 10 x 1	378-011
FILTER, LIGHT PLEXI 5" Green w/cam hole	378-514
FILTER, JEWEL LIGHT PILOT, Red	378-518
FILTER, GRATICULE 5", 6 cm Vert. x 10 cm Horiz.	331-037
GROMMET, RUBBER, $1/4$	348-002
GROMMET, RUBBER, $5/16$	348-003
GROMMET, RUBBER, $3/8$	348-004
GROMMET, RUBBER, $1/2$	348-005
GROMMET, RUBBER, $3/4$	348-006
GROMMET, RUBBER, $5/8$	348-012
HANDLE, w/hardware	367-011
HOLDER, NYLON, NEON, Double Molded $7/8$ x 1.088	352-006
HOLDER, NYLON, NEON, Single	352-008
HOLDER, FUSE, 3 AG	352-010
HOLDER, NYLON $1/4$" dia. Coil Form x $1\frac{1}{8}$ lg.	352-013
HOUSING, AIR FILTER, ALUM., .063 x $10\frac{1}{2}$ x $10\frac{1}{2}$ x 1 deep blue wrinkle (20001-20949)	380-008
HOUSING, AIR FILTER, ALUM., .063 x $10\frac{1}{2}$ x $10\frac{1}{2}$ x 1 deep blue vinyl (20950-up)	380-018
KNOB, SMALL RED, .694 dia. x $13/32$ hi. $3/16$ insert hole	366-032
KNOB, SMALL BLACK, .694 dia. x $1/2$ hi. $1/4$ insert hole	366-033
KNOB, SMALL RED, .780 OD x .451 hi. $1/8$ hole part way	366-038

Mechanical Parts List *(continued)*

	Tektronix Part Number
KNOB, SMALL RED, .780 OD x .451 hi. $\frac{3}{16}$ hole part way	366-039
KNOB, LARGE BLACK 1.375 OD x .650 hi. $\frac{1}{4}$ hole thru	366-040
KNOB, LARGE BLACK 1.375 OD x .650 hi. $\frac{1}{4}$ hole part way	366-042
KNOB, LARGE BLACK 1.375 OD x .650 hi. $\frac{17}{64}$ hole thru	366-046
KNOB, LARGE BLACK 1.625 OD x .655 hi. .250 ID thru	366-058
KNOB, LARGE BLACK 1.625 OD x .655 hi. $\frac{1}{4}$ hole part way	366-060
LOCKWASHER, STEEL INT #4	210-004
LOCKWASHER, STEEL INT #6	210-006
LOCKWASHER, STEEL EXT #8	210-007
LOCKWASHER, STEEL INT #8	210-008
LOCKWASHER, STEEL INT #10	210-010
LOCKWASHER, STEEL INT $\frac{1}{4}$	210-011
LOCKWASHER, STEEL POT INT $\frac{3}{8}$ x $\frac{1}{2}$	210-012
LOCKWASHER, STEEL INT $\frac{3}{8}$ x $\frac{11}{16}$	210-013
LOCKWASHER, STEEL #5 Cad Plated, Spring	210-017
LOCKWASHER, INT. $\frac{1}{4}$	210-046
LUG, SOLDER, SE4	210-201
LUG, SOLDER, SE6	210-202
LUG, SOLDER, SE8	210-205
LUG, SOLDER, SE10 long	210-206
LUG, SOLDER, POT PLAIN $\frac{3}{8}$	210-207
LUG, SOLDER, $\frac{1}{4}$ hole lock round perimeter, .018 thick	210-223
LUG, SOLDER, #10 non-locking $\frac{7}{8}$" lg.	210-224
LUG, SOLDER, SE8 long	210-228
MOUNT, FAN MOTOR 7"	426-047
NUT, CAP HEX BRASS $\frac{1}{4}$ x $\frac{5}{16}$	210-402
NUT, HEX BRASS 4-40 x $\frac{3}{16}$	210-406
NUT, HEX BRASS 6-32 x $\frac{1}{4}$	210-407
NUT, HEX BRASS 8-32 x $\frac{5}{16}$	210-409
NUT, HEX BRASS 10-32 x $\frac{5}{16}$	210-410
NUT, HEX BRASS $\frac{3}{8}$-32 x $\frac{1}{2}$	210-413
NUT, HEX BRASS $\frac{15}{32}$-32 x $\frac{9}{16}$	210-414
NUT, KNURLED BRASS, Graticule $\frac{3}{8}$-24 x $\frac{9}{16}$ x $\frac{3}{16}$	210-424
NUT, HEX ALUM., $\frac{1}{2}$" x $\frac{5}{8}$" lg. $\frac{3}{8}$-32 Int. thread (pot)	210-444
NUT, HEX STEEL 10-32 x $\frac{3}{8}$ x $\frac{1}{8}$ thick	210-445
NUT, HEX BRASS 5-40 x $\frac{1}{4}$ Cad Plated (or $\frac{3}{16}$) w/switch	210-449
NUT, HEX STEEL $\frac{1}{4}$-28 x $\frac{3}{8}$ x $\frac{3}{32}$	210-455
NUT, KEPS STEEL 6-32 x $\frac{5}{16}$	210-457
NUT, KEPS STEEL 8-32 x $\frac{11}{32}$	210-458
NUT, HEX ALUM., 8-32 x $\frac{1}{2}$ x $\frac{23}{64}$ thick body, Rest. Mtg.	210-462
NUT, POT MINIATURE, HEX ALUM., $\frac{1}{4}$-32 x $\frac{5}{16}$ dia. x $\frac{19}{32}$ lg.	210-471

Mechanical Parts List *(continued)*

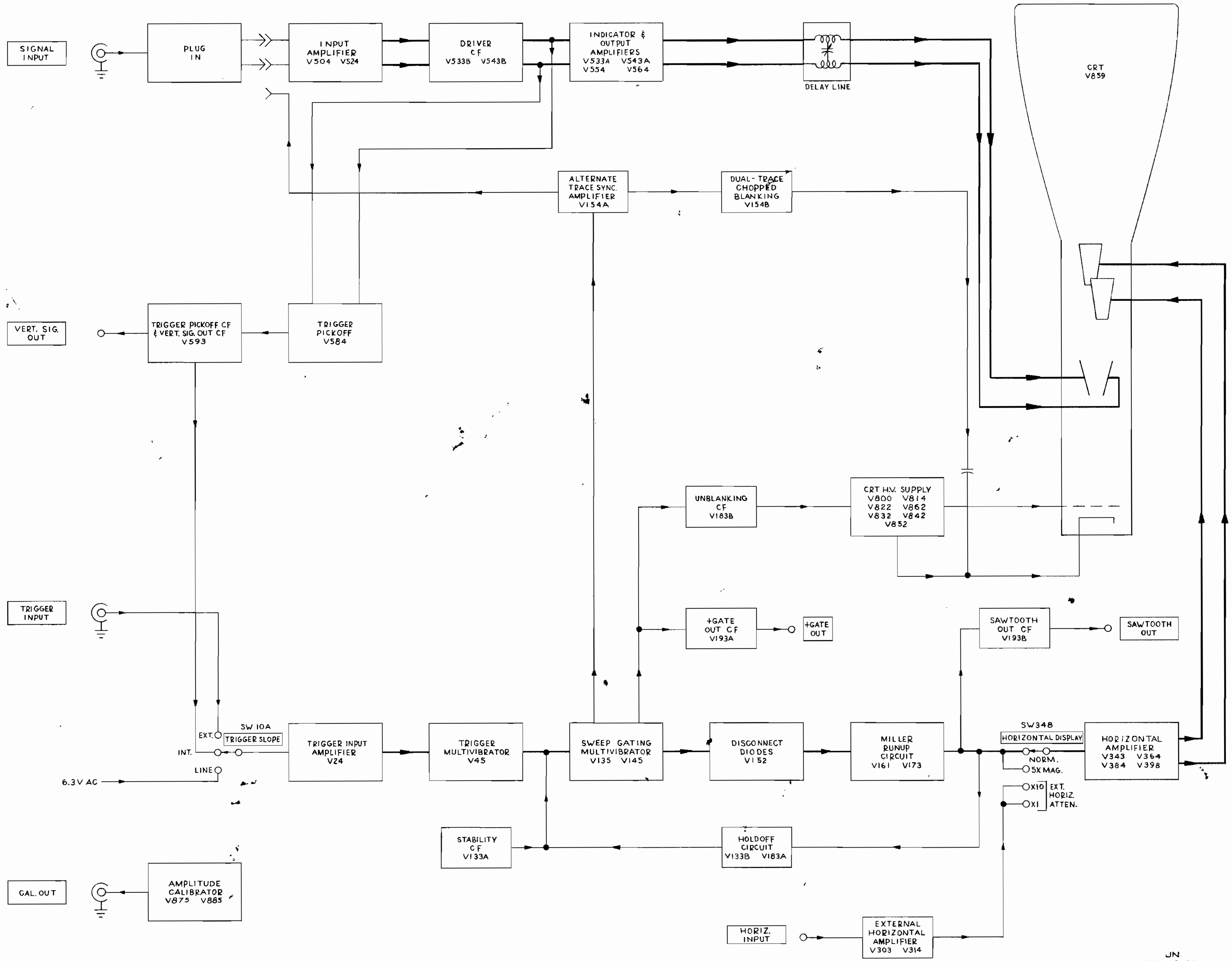
	Tektronix Part Number
NUT, SWITCH BRASS $^{15}/_{32}$-32 x $^{5}/_{64}$, 12-sided	210-473
NUT, HEX ALUM., 6-32 x $^{5}/_{16}$ x .194 body, 5-10w Res. Mtg.	210-478
NUT, HEX 10-32 x $^{3}/_{8}$ x $^{1}/_{8}$	210-564
NUT, KEPS STEEL 10-32 x $^{3}/_{8}$	220-410
PANEL, FRONT	333-478
PLATE, ALUM., .125 x $5^{11}/_{16}$ x $6^{11}/_{16}$ Plug-In Housing Back	386-355
PLATE, BAKELITE, $^{3}/_{32}$ x $2^{3}/_{4}$ x $5^{1}/_{4}$	386-358
PLATE, BRASS, .040 x $^{9}/_{16}$ x $1^{17}/_{32}$ Connecting	386-374
PLATE, ALUM., .063 x $9^{1}/_{8}$ x $6^{7}/_{16}$ Plug-In Housing Side	Use 386-680
PLATE, PLEXIGLAS, .100 x 2 x $11^{7}/_{8}$ Delay Housing Side	Use 387-788
PLATE, PLEXIGLAS, .100 x $2^{1}/_{4}$ x $8^{1}/_{8}$ Delay Line	Use 387-789
PLATE, SUBPANEL, REAR	386-766
PLATE, ALUM., .080 x $11^{5}/_{8}$ x $11^{1}/_{2}$	386-886
PLATE, SUBPANEL, FRONT	386-888
PLATE, ALUM., CAB. BOTTOM, Blue Wrinkle (20001-20949)	386-597
PLATE, ALUM., CAB. BOTTOM, .050 x $20^{3}/_{8}$ x $10^{43}/_{64}$ textured Blue wrinkle (20950-24059)	387-061
PLATE, ALUM., CAB. BOTTOM (24060-up)	387-478
PLATE, ALUM., DE Right Blue wrinkle (20001-20949)	386-770
PLATE, CAB. SIDE, w/box textured, Blue wrinkle (20950-up)	387-076
PLATE, CAB. SIDE, LEFT, textured, Blue wrinkle (20001-20949)	386-736
PLATE, CAB. SIDE, LEFT, textured, Blue wrinkle (20950-up)	387-077
PLATE, REAR OVERLAY, textured, Blue wrinkle (20001-20949)	386-767
PLATE, REAR OVERLAY, textured, Blue wrinkle (20950-up)	387-078
PLUG, CRT CONTACT, BRASS	134-031
POST, BINDING, 5-way, stem & cap	129-036
POST, BINDING, Long, BPN13	129-051
POST, BINDING, Short, BPN13	129-053
RING, FAN ALUM., .063 x $7^{3}/_{8}$ ID, w/mtg. ears	354-053
RING, LOCKING SWITCH, $^{23}/_{32}$ OD x $^{15}/_{32}$ ID	354-055
RING, ROTATING (20001-20409)	354-066
RING, CRT ROTATOR (20410-23759)	050-063
RING, 2.40 OD x $2^{11}/_{16}$ ID x $^{3}/_{16}$, CRT Rotator (23760-up)	354-178
RING, CLAMPING	354-103
ROD, SPACING ALUM., $^{1}/_{4}$ x $3^{1}/_{8}$ tapped 6-32, both ends	384-135
ROD, EXT. STEEL $^{1}/_{8}$ x $8^{7}/_{16}$	384-162
ROD, NYLON, $^{5}/_{16}$ dia. x $^{5}/_{8}$ tapped 6-32 thru w/#18 hole	385-033
ROD, NYLON, $^{5}/_{16}$ dia. x $^{3}/_{4}$ tapped 6-32 one end w/#44 hole	385-073
ROD, NYLON, $^{5}/_{16}$ dia. x 1 tapped 6-32 one end w/#44 hole	385-074
ROD, NYLON, $^{5}/_{16}$ dia. x $1^{5}/_{8}$ tapped 6-32 one end w/#44 hole	385-076
ROD, ALUM., HEX $^{1}/_{4}$ x $^{7}/_{16}$	385-080
ROD, NYLON, $^{5}/_{16}$ dia. x $2^{1}/_{4}$ tapped 6-32 one end w/2 #44 holes	385-082
ROD, NYLON, $^{5}/_{16}$ x $1^{9}/_{16}$ tapped 6-32 both ends	385-090

	Tektronix Part Number
ROD, NYLON, $\frac{1}{4}$ x 1$\frac{1}{4}$ tapped 6-32 one end w/3 #44 holes thru	385-096
ROD, ALUM., $\frac{1}{4}$ x 3$\frac{5}{16}$ tapped 6-32 both ends 20001-24059	385-106
ROD, ALUM., Hex, transf. support 24060-up	384-599
SCREW 4-40 x $\frac{5}{16}$ BHS	211-011
SCREW 4-40 x $\frac{3}{8}$ RHS	211-013
SCREW 4-40 x $\frac{5}{8}$ RHS	211-016
SCREW 4-40 x $\frac{1}{4}$ FHS	211-023
SCREW 4-40 x $\frac{3}{8}$ FHS	211-025
SCREW 4-40 x 1 FHS	211-031
SCREW 4-40 x $\frac{5}{16}$ Pan HS w/lockwasher	211-033
SCREW 6-32 x $\frac{3}{16}$ BHS	211-503
SCREW 6-32 x $\frac{1}{4}$ BHS	211-504
SCREW 6-32 x $\frac{5}{16}$ BHS	211-507
SCREW 6-32 x $\frac{3}{8}$ BHS	211-510
SCREW 6-32 x $\frac{1}{2}$ BHS	211-511
SCREW 6-32 x $\frac{5}{8}$ FHS	211-522
SCREW 6-32 x $\frac{5}{16}$ Pan HS w/lockwasher	211-534
SCREW 6-32 x $\frac{3}{8}$ Truss HS Phillips	211-537
SCREW 6-32 x $\frac{5}{16}$ FHS 100° CSK Phillips	211-538
SCREW 6-32 x $\frac{1}{2}$ FIL HS	211-539
SCREW 6-32 x $\frac{1}{4}$ FHS 100° CSK Phillips	211-541
SCREW 6-32 x $\frac{5}{16}$ Truss HS Phillips	211-542
SCREW 6-32 x $\frac{3}{4}$ THS	211-544
SCREW 6-32 x $\frac{5}{16}$ RHS	211-543
SCREW 6-32 x 1$\frac{1}{2}$ RHS	211-553
SCREW 6-32 x $\frac{3}{8}$ FHS 100° CSK Phillips	211-559
SCREW 6-32 x $\frac{1}{4}$ Truss HS Phillips	211-565
SCREW 8-32 x $\frac{5}{16}$ BHS	212-004
SCREW 8-32 x $\frac{1}{2}$ BHS	212-008
SCREW 8-32 x 1$\frac{1}{2}$ RHS	212-022
SCREW 8-32 x $\frac{3}{8}$ BHS	212-023
SCREW 8-32 x 1$\frac{1}{4}$ RHS	212-031
SCREW 8-32 x 1$\frac{3}{4}$ Fil HS	212-037
SCREW 8-32 x $\frac{3}{8}$ Truss Phillips	212-039
SCREW 8-32 x $\frac{3}{8}$ FHS 100° CSK Phillips	212-040
SCREW 10-32 x 3 HHS	212-511
SCREW 10-32 x 3$\frac{1}{4}$ RHS	212-524
SCREW, THREAD CUTTING, 4-40 x $\frac{3}{8}$ FHS	213-012
SCREW, THREAD CUTTING, 6-32 x $\frac{3}{8}$ Truss HS Phillips	213-041
SCREW, THREAD CUTTING, 5-32 x $\frac{3}{16}$ Pan HS Phillips	213-044
SCREW, THREAD FORMING #4 x $\frac{1}{4}$ Type B	213-088
SCREW, THREAD FORMING, 6-32 x $\frac{3}{8}$ THS	213-104
SHIELD, SOCKET $\frac{29}{32}$ ID	337-005

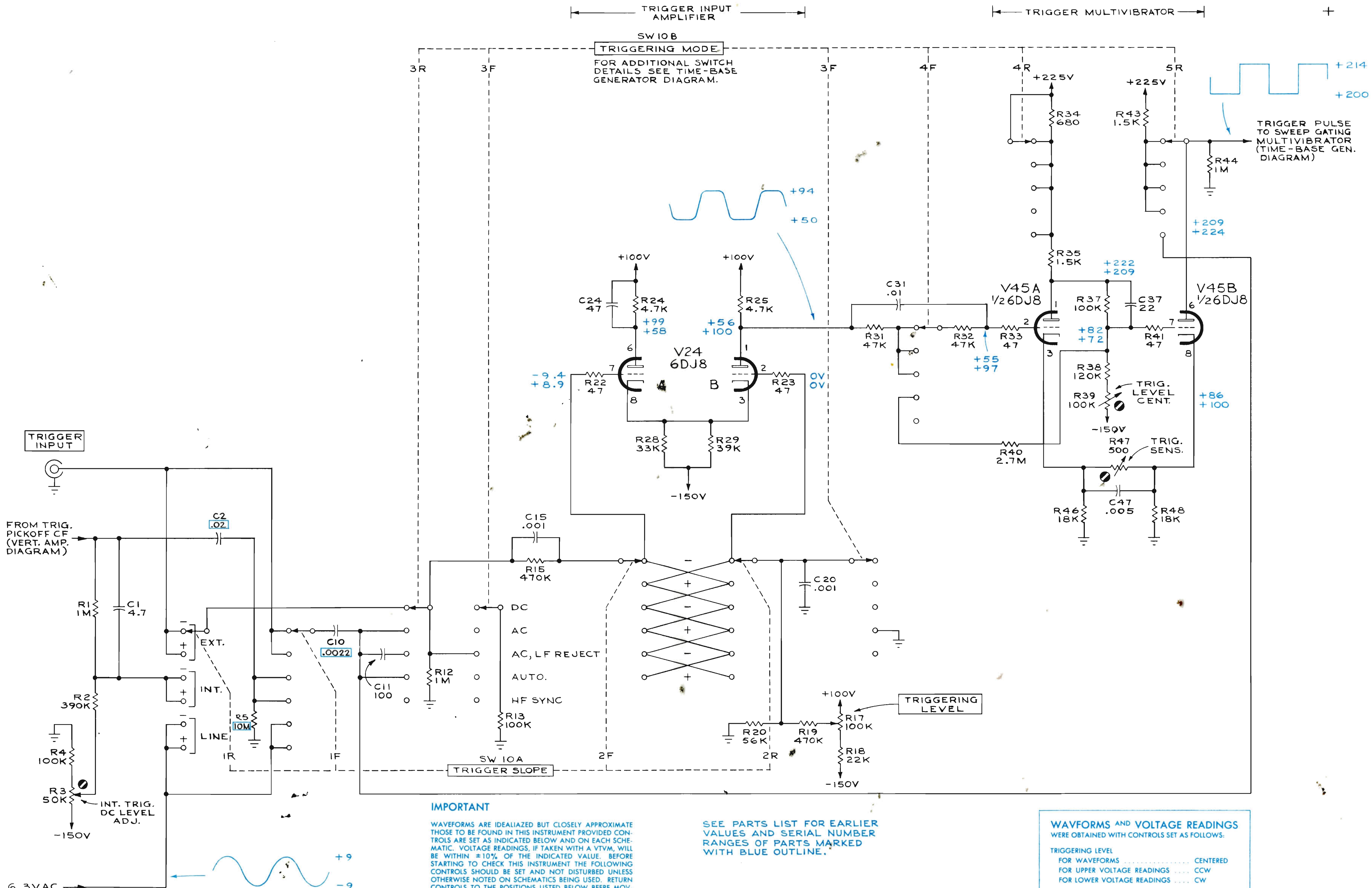
	Tektronix Part Number
SHIELD, TUBE $1\frac{1}{32}$ ID w/spring $1\frac{15}{16}$ hi.	337-008
SHIELD, TUBE $1\frac{1}{32}$ ID	337-009
SHIELD, HOUSING TOP	337-066
SHIELD, PLUG-IN HOUSING $7\frac{7}{8} \times 6\frac{13}{32}$	337-091
SHIELD, F & I	337-148
SHIELD, 5" GRATICULE LIGHT	337-187
SHIELD, HV	337-287
SHIELD, RECTIFIER	337-288
SHIELD, UPPER CAL SW.	337-290
SHIELD, LOWER CAL SW.	337-291
SHOCKMOUNT, $\frac{1}{2}$" dia. x $\frac{1}{2}$" high	348-008
SOCKET, GRATICULE LAMP	136-001
SOCKET, STM7G	136-008
SOCKET, STM8 Ground	136-011
SOCKET, STM9G	136-015
SOCKET, STM14	136-019
SOCKET, LIGHT JEWEL	136-025
SOCKET, TIP JACK	136-037
SPACER, $\frac{1}{16}$" nylon mold, ceramic strips	361-007
SPACER, $\frac{3}{16}$" nylon mold, ceramic strips	361-008
SPACER, $\frac{5}{16}$" nylon mold, ceramic strips	361-009
STRAP, MOUNTING, HV TRANSFORMER	346-001
STRIP, FELT	124-068
STRIP, CERAMIC $\frac{3}{4} \times 2$ notches, clip-mounted	124-086
STRIP, CERAMIC $\frac{3}{4} \times 3$ notches, clip-mounted	124-087
STRIP, CERAMIC $\frac{3}{4} \times 4$ notches, clip-mounted	124-088
STRIP, CERAMIC $\frac{3}{4} \times 7$ notches, clip-mounted	124-089
STRIP, CERAMIC $\frac{3}{4} \times 9$ notches, clip-mounted	124-090
STRIP, CERAMIC $\frac{3}{4} \times 11$ notches, clip-mounted	124-091
STRIP, CERAMIC $\frac{3}{4} \times 1$ notches, clip-mounted	124-100
STUD, STEEL 10-32 x $2\frac{7}{16}$	355-044
STUD, STEEL, CRT Rotator	355-049
TAG, VOLTAGE RATING 117V 105-125, 50-60 cycles	334-005
TUBE, SPACING ALUM., .180 ID x $\frac{1}{4}$ OD x $1\frac{23}{32}$	166-099
TUBE, FORM COIL ZYTEL, RETAINING	166-103

Mechanical Parts List *(continued)*

	Tektronix Part Number
TUBE, SPACING ALUM., .245 ID x $^3/_8$ OD x 2$^{19}/_{32}$	166-105
TUBE, SPACING ALUM., .180 ID x $^1/_4$ OD x $^7/_{32}$	166-107
WASHER, STEEL 6L x $^3/_8$ x .032	210-803
WASHER, STEEL 8S x $^3/_8$ x .032	210-804
WASHER, BRASS Centering Zinc Plated	210-809
WASHER, FIBER #6 Shouldered	210-811
WASHER, FIBER #10	210-812
WASHER, RUBBER WAN 13-20	210-816
WASHER, STEEL .390 ID x $^9/_{16}$ OD x .020	210-840
WASHER, STEEL .119 ID x $^3/_8$ OD x .025 (#4L)	210-851
WASHER, RUBBER For fuse holder	210-873
WASHER, STEEL .470 ID x $^{21}/_{32}$ OD x .030 flat	210-902
WASHER, WAVY, PHOS. BRONZE	210-914



BLOCK DIAGRAM



IMPORTANT

WAVEFORMS ARE IDEALIAZED BUT CLOSELY APPROXIMATE THOSE TO BE FOUND IN THIS INSTRUMENT PROVIDED CONTROLS ARE SET AS INDICATED BELOW AND ON EACH SCHEMATIC. VOLTAGE READINGS, IF TAKEN WITH A VTVM, WILL BE WITHIN ±10% OF THE INDICATED VALUE. BEFORE STARTING TO CHECK THIS INSTRUMENT THE FOLLOWING CONTROLS SHOULD BE SET AND NOT DISTURBED UNLESS OTHERWISE NOTED ON SCHEMATICS BEING USED. RETURN CONTROLS TO THE POSITIONS LISTED BELOW BEFRE MOVING TO THE NEXT SCHEMATIC.

AMPLITUDE CALIBRATOR	OFF
HORIZONTAL DISPLAY	TIME-BASE (NORM.)
VARIABLE (TIME/CM)	CW (CALIBRATED)
TIME/CM	1 mSEC
TRIGGERING MODE	AC
TRIGGER SLOPE	+LINE
TRIGGERING LEVEL	CENTERED
STABILITY	PRESET

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

WAVFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

TRIGGERING LEVEL
- FOR WAVEFORMS .... CENTERED
- FOR UPPER VOLTAGE READINGS .... CCW
- FOR LOWER VOLTAGE READINGS .... CW

SEE ALSO **IMPORTANT** NOTE ON THIS DIAGRAM.

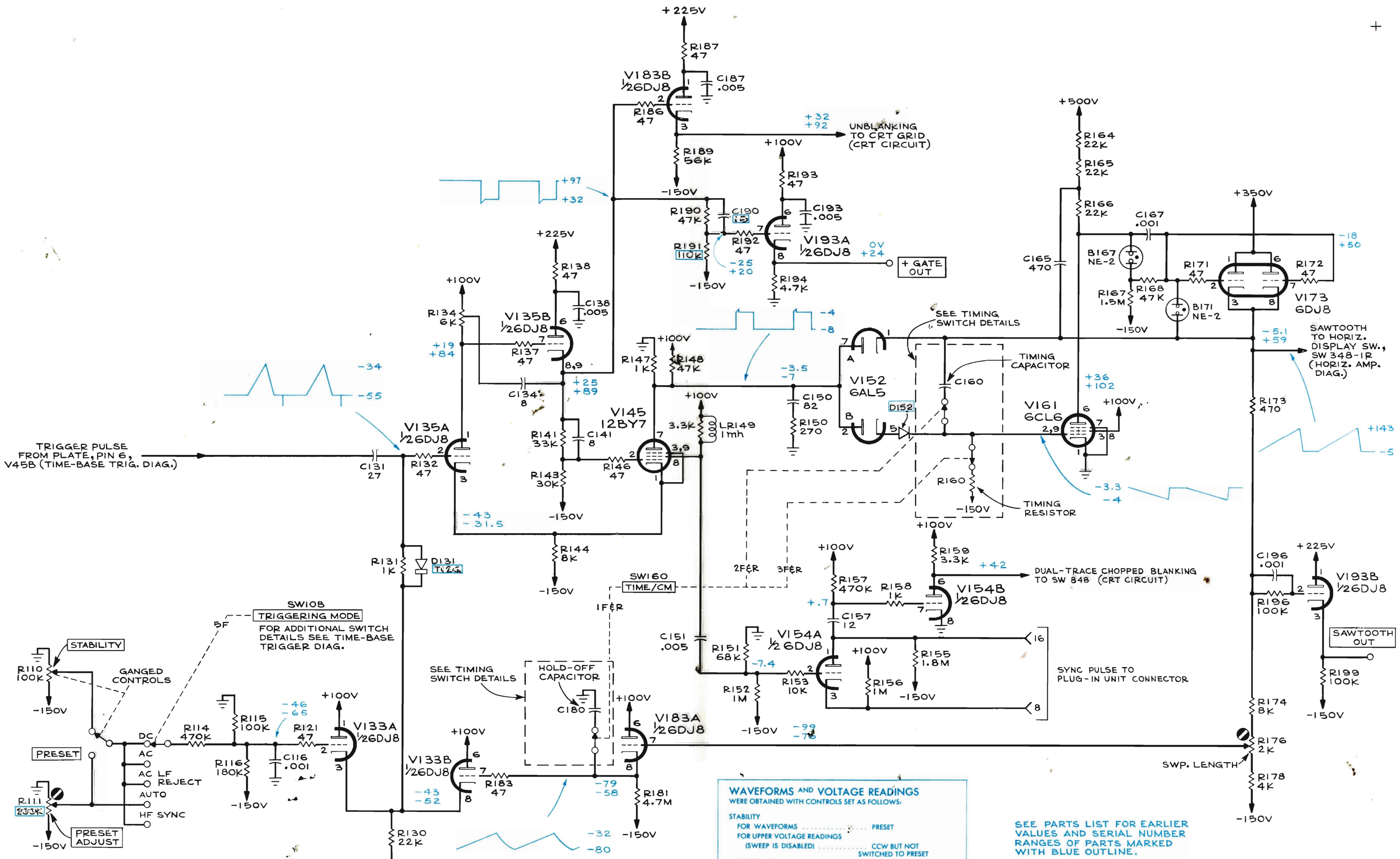
531 A TIME-BASE TRIG.

MRH
664

TYPE 531A OSCILLOSCOPE

C

TIME-BASE TRIGGER



WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

STABILITY
FOR WAVEFORMS .... PRESET
FOR UPPER VOLTAGE READINGS (SWEEP IS DISABLED) .... CCW BUT NOT SWITCHED TO PRESET
FOR LOWER VOLTAGE READINGS (SWEEP FREE RUNS) .... CW

SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

531A A TIME-BASE GEN.

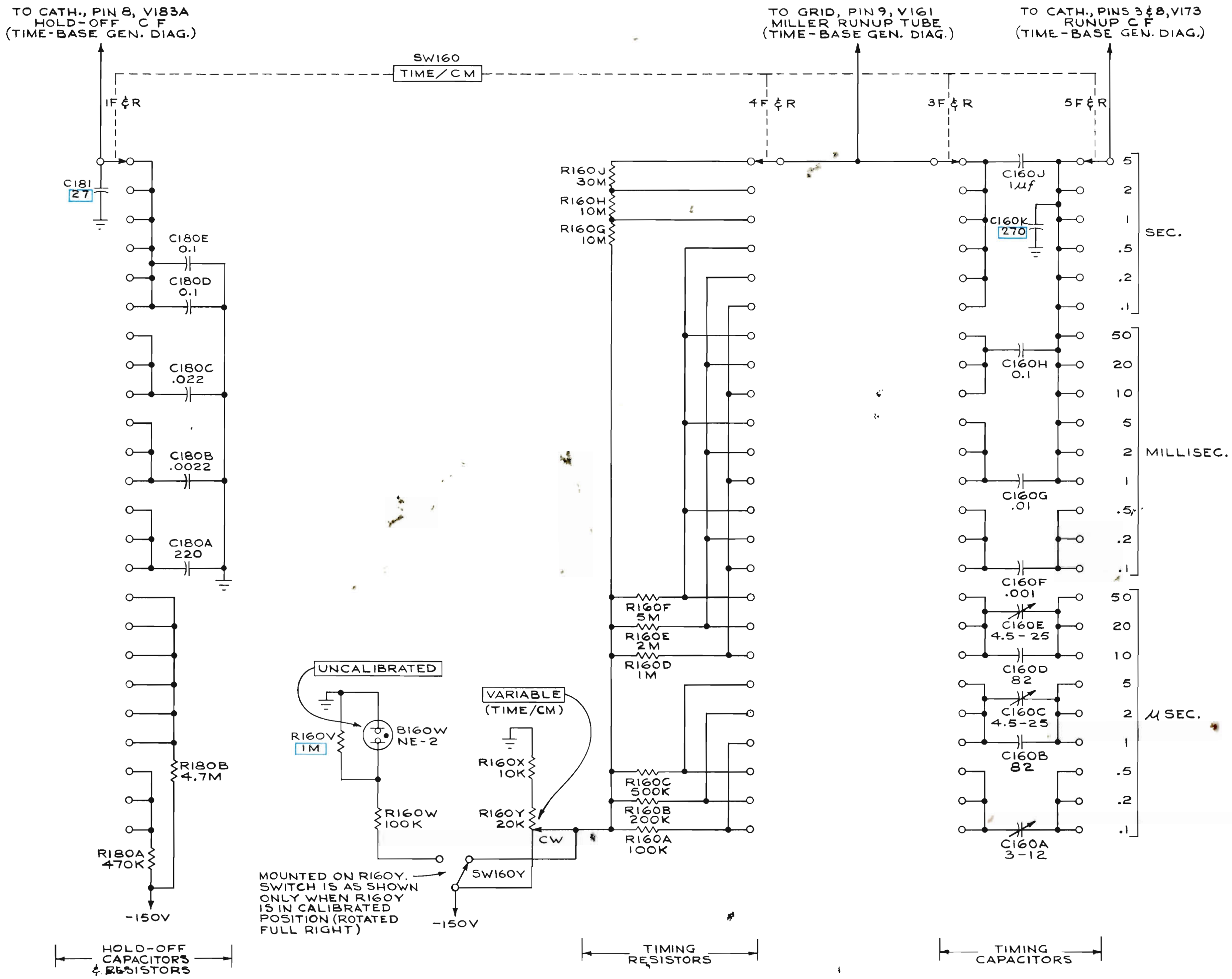
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

1066

TYPE 531A OSCILLOSCOPE

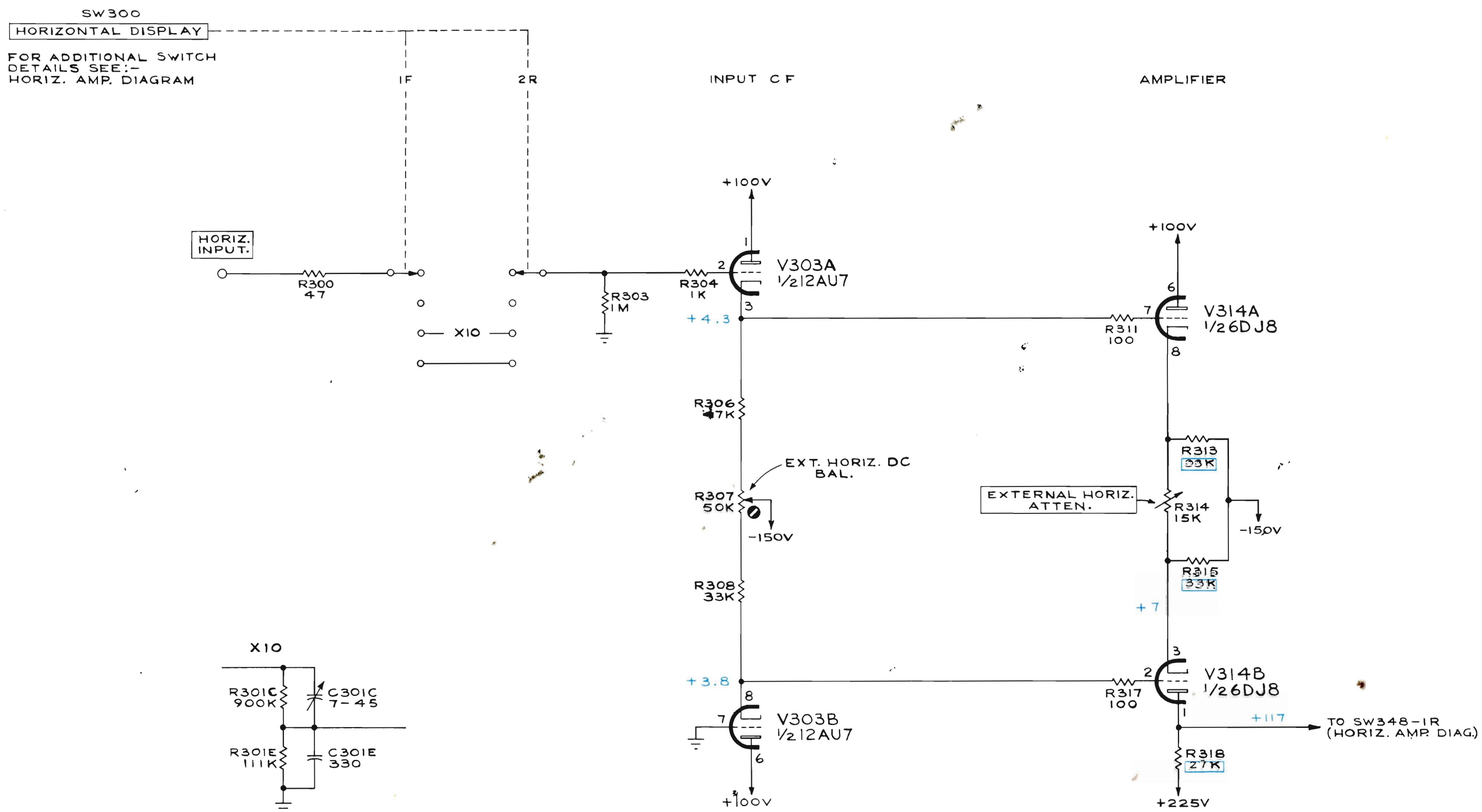
E

TIME-BASE GENERATOR



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

MRH
664



VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

EXTERNAL HORIZONTAL INPUT SIGNAL . . . NONE
HORIZONTAL DISPLAY . . . . EXT. HORIZ. (X10) ATTEN.
EXTERNAL HORIZ. ATTENUATOR 10-1 . . . CW

SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

531A A EXT HORIZ. AMP.

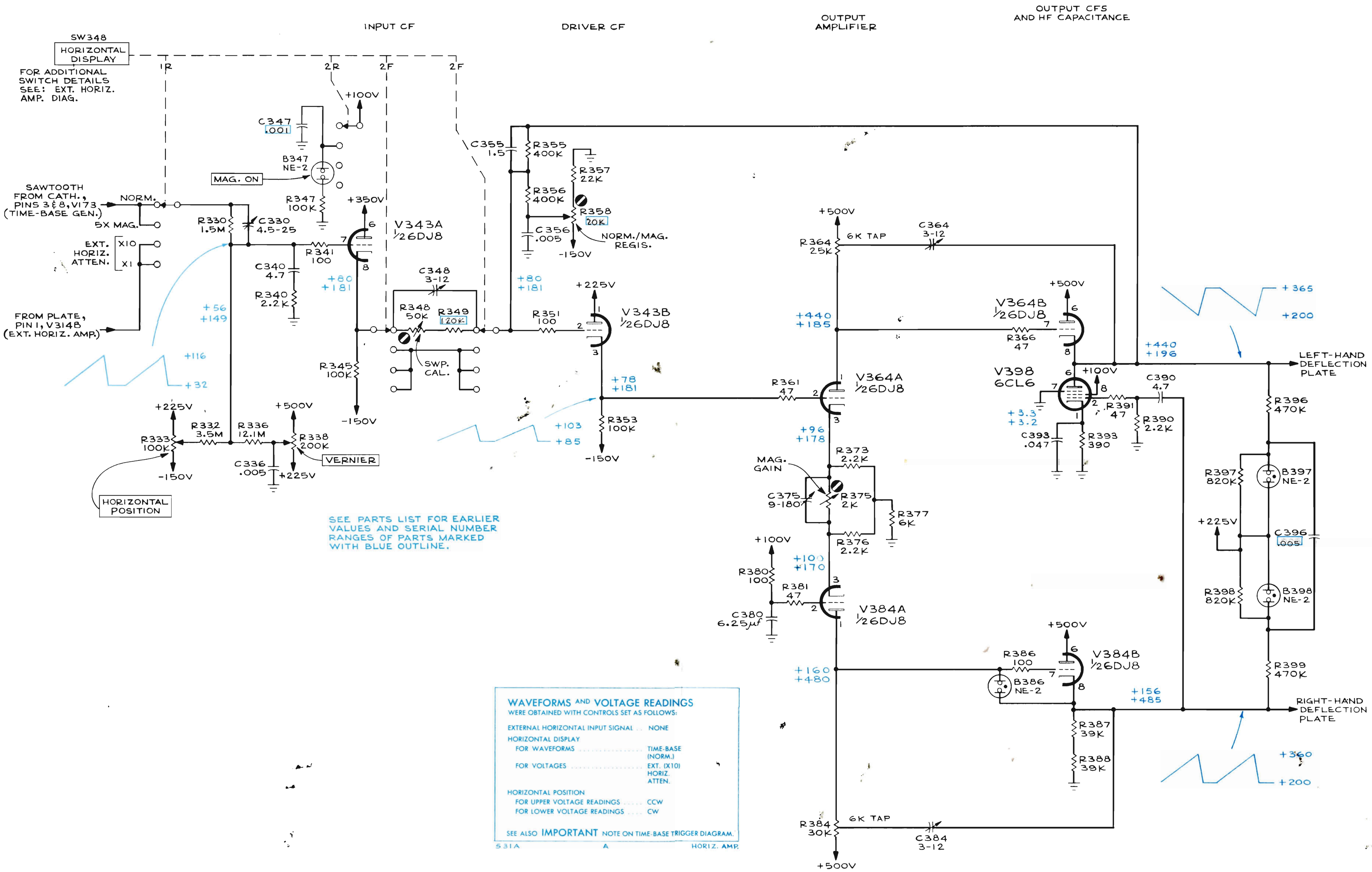
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

665
MRH

TYPE 531A OSCILLOSCOPE

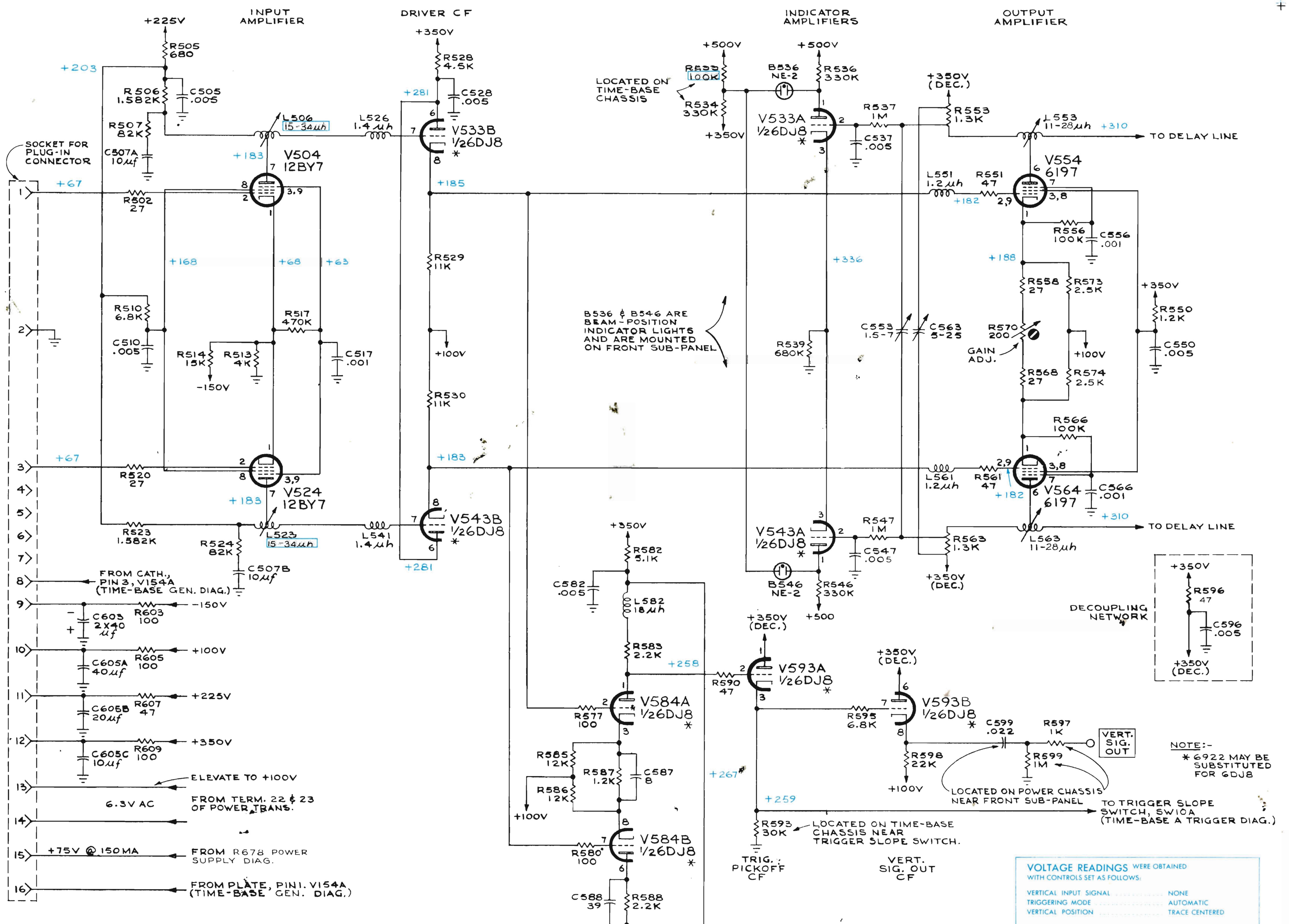
B

EXTERNAL HORIZONTAL AMPLIFIER



SW348 HORIZONTAL DISPLAY
FOR ADDITIONAL SWITCH DETAILS SEE: EXT. HORIZ. AMP. DIAG.
1R 2R 2F 2F
INPUT CF
DRIVER CF
OUTPUT AMPLIFIER
OUTPUT CFS AND HF CAPACITANCE
SAWTOOTH FROM CATH., PINS 3 & 8, V173 (TIME-BASE GEN.)
NORM.
5X MAG.
EXT. HORIZ. ATTEN. X10 X1
FROM PLATE, PIN 1, V314B (EXT. HORIZ. AMP.)
MAG. ON
C347 .001
B347 NE-2
R347 100K
+100V
+350V
R330 1.5M
C330 4.5-25
R341 100
C340 4.7
R340 2.2K
V343A ½6DJ8
+56 +149
+116
+32
+80 +181
C348 3-12
R348 50K
R349 120K
SWP. CAL.
R345 100K
-150V
+225V
R333 100K
R332 3.5M
R336 12.1M
+500V
R338 200K
VERNIER
C336 .005
+225V
-150V
HORIZONTAL POSITION
C355 1.5
R355 400K
R356 400K
R357 22K
R358 20K
NORM./MAG. REGIS.
C356 .005
-150V
+80 +181
+225V
R351 100
V343B ½6DJ8
+78 +181
+103 +85
R353 100K
-150V
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.
+500V
R364 25K
6K TAP
C364 3-12
+440 +185
R361 47
V364A ½6DJ8
+96 +178
MAG. GAIN
R373 2.2K
C375 9-180
R375 2K
R377 6K
R376 2.2K
+100V
R380 100
+100 +170
R381 47
V384A ½6DJ8
C380 6.25μf
+160 +480
R384 30K
6K TAP
C384 3-12
+500V
+500V
V364B ½6DJ8
R366 47
V398 6CL6
+100V
R391 47
C390 4.7
R390 2.2K
+3.3 +3.2
C393 .047
R393 390
+440 +196
+365
+200
LEFT-HAND DEFLECTION PLATE
R396 470K
R397 820K
B397 NE-2
+225V
C396 .005
R398 820K
B398 NE-2
R399 470K
+500V
R386 100
B386 NE-2
V384B ½6DJ8
+156 +485
R387 39K
R388 39K
RIGHT-HAND DEFLECTION PLATE
+360
+200
WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:
EXTERNAL HORIZONTAL INPUT SIGNAL ... NONE
HORIZONTAL DISPLAY
FOR WAVEFORMS ... TIME-BASE (NORM.)
FOR VOLTAGES ... EXT. (X10) HORIZ. ATTEN.
HORIZONTAL POSITION
FOR UPPER VOLTAGE READINGS ... CCW
FOR LOWER VOLTAGE READINGS ... CW
SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.
531A A HORIZ. AMP.

664
TP



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

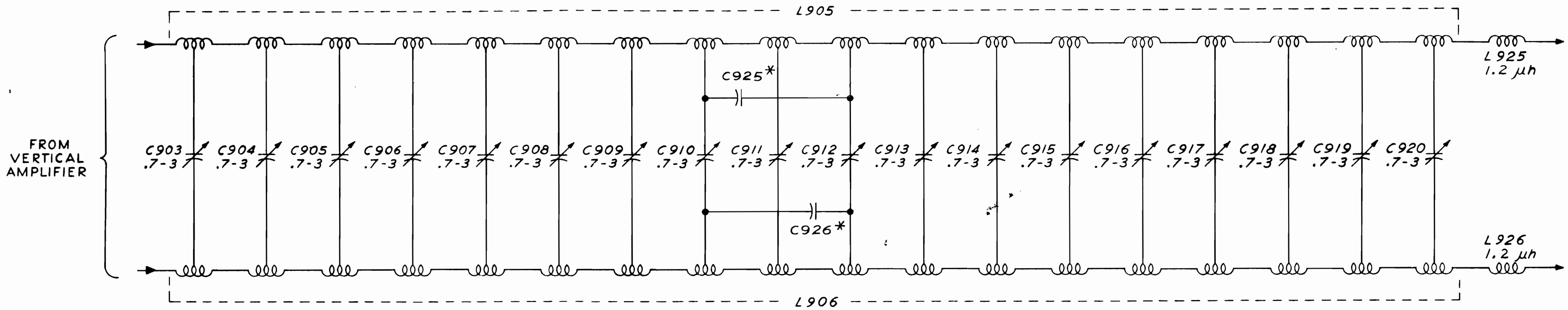
VERTICAL INPUT SIGNAL	NONE
TRIGGERING MODE	AUTOMATIC
VERTICAL POSITION	TRACE CENTERED

SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

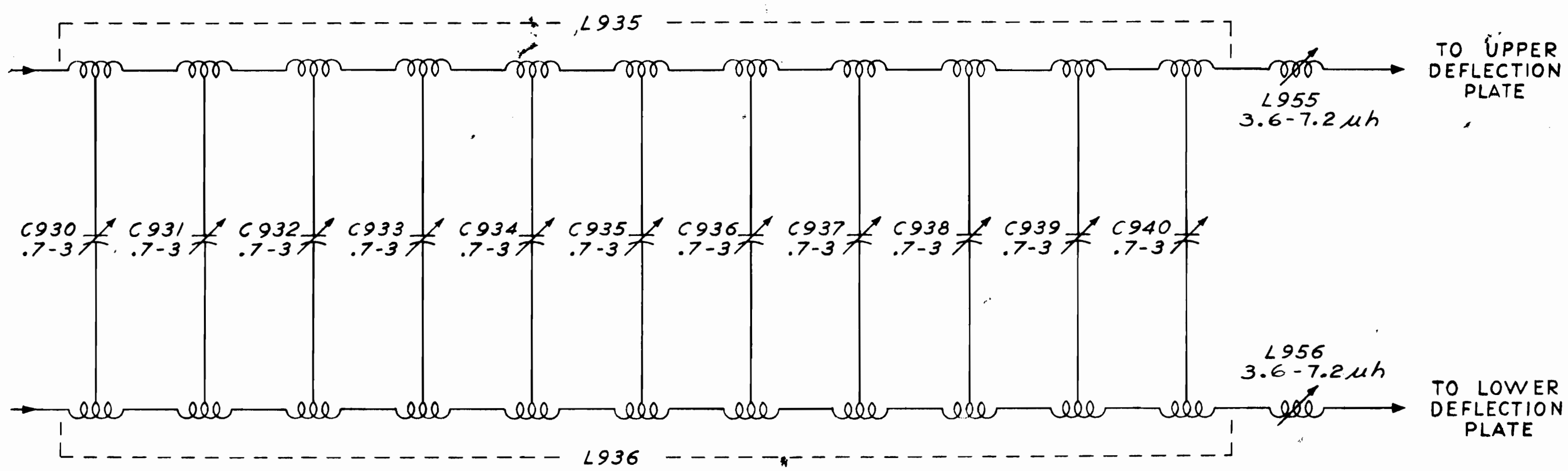
MRH 6-64

TYPE 531 A OSCILLOSCOPE

VERTICAL AMPLIFIER



* SEE PARTS LIST

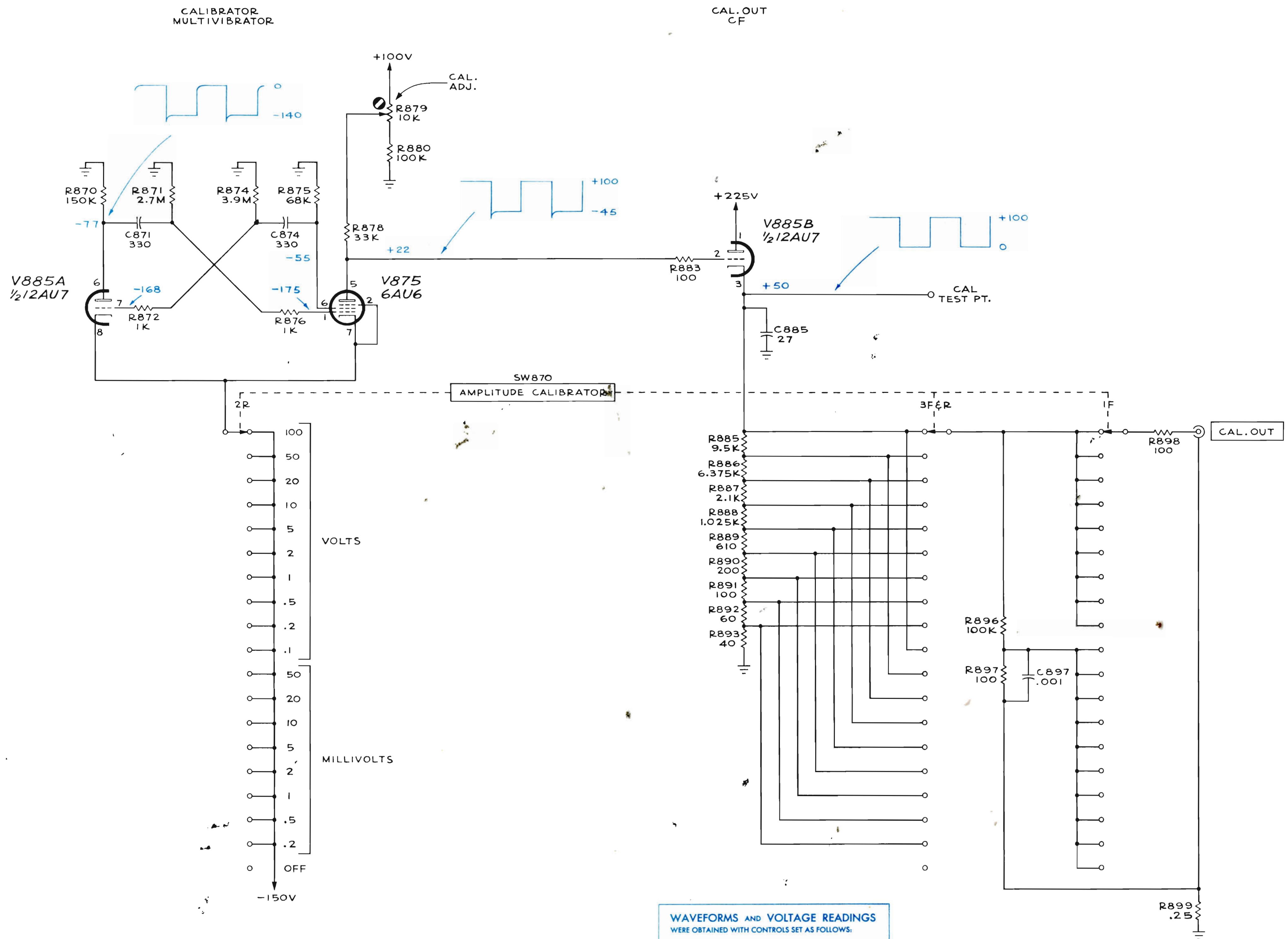


11-16-61 JR

TYPE 531A OSCILLOSCOPE

B_2

DELAY LINE NETWORK



WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:
AMPLITUDE CALIBRATOR .... ON

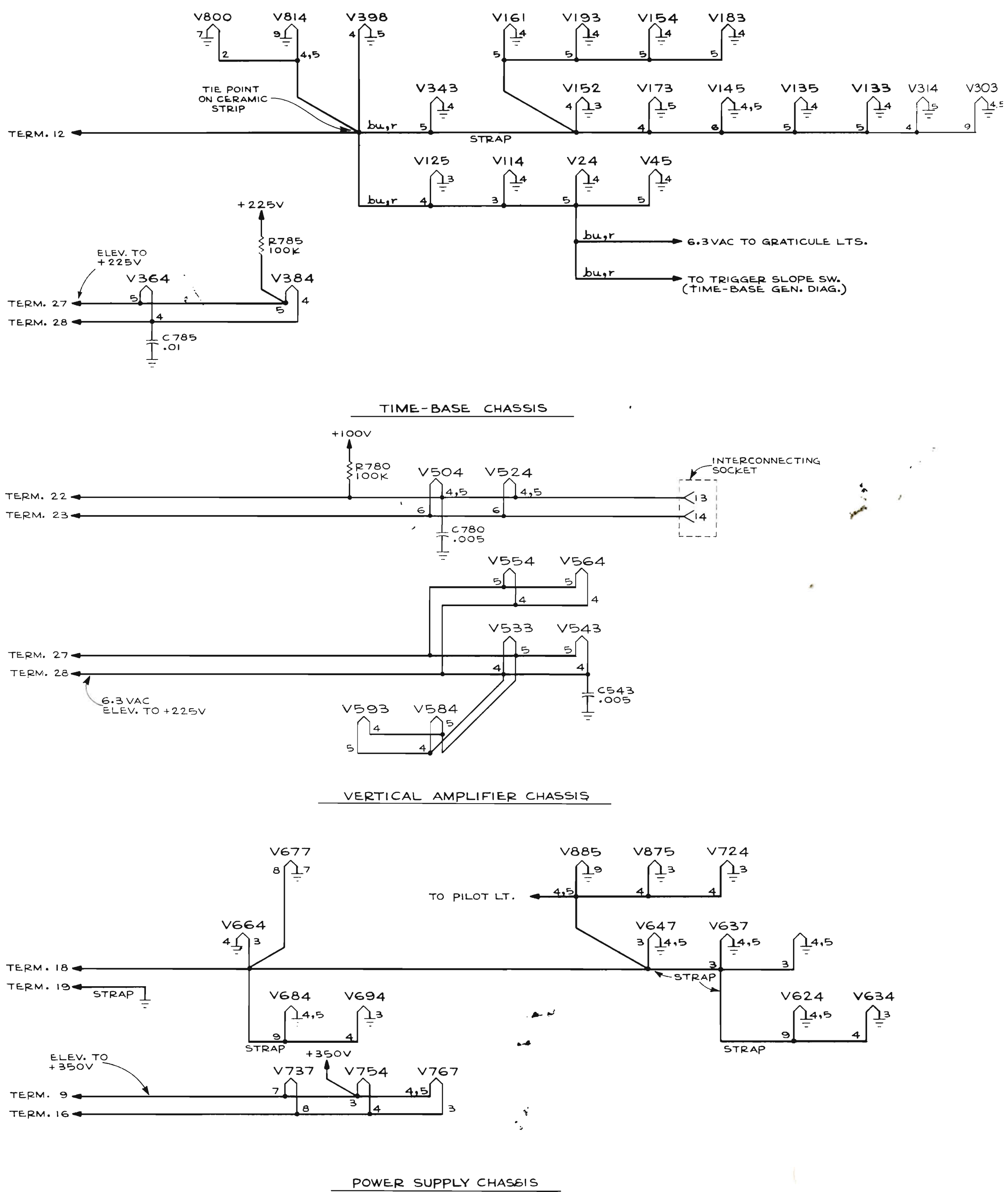
531A A CALIBRATOR

GAB
2-7-62

TYPE 531A OSCILLOSCOPE

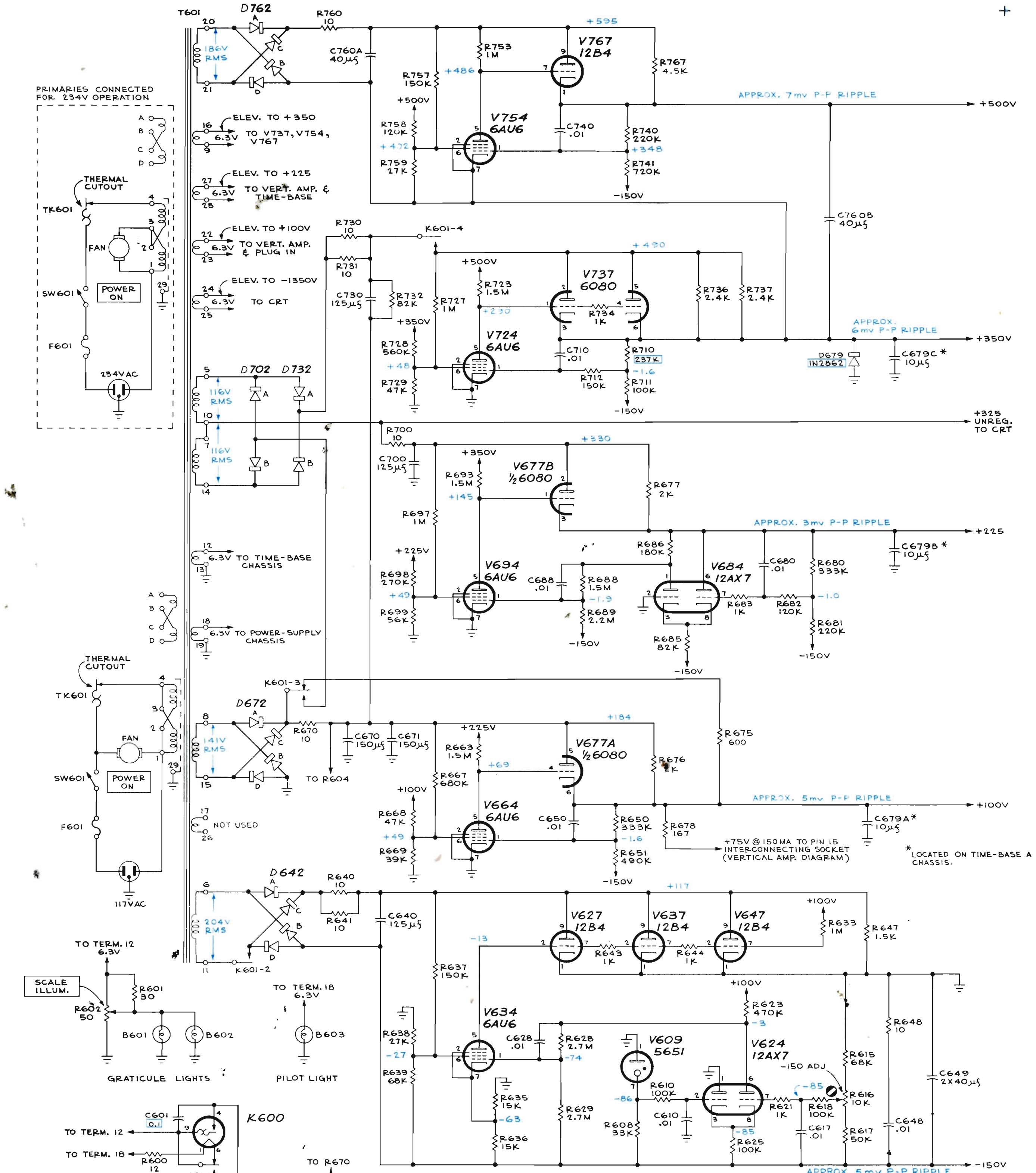
A5

CALIBRATOR



TYPE 531A OSCILLOSCOPE

HEATER WIRING DIAGRAM



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

PEAK TO PEAK RIPPLE AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

VERTICAL INPUT SIGNAL	NONE
TRIGGER INPUT SIGNAL	NONE
LINE VOLTAGE	117 V AC
STABILITY	CCW BUT NOT SWITCHED TO PRESET

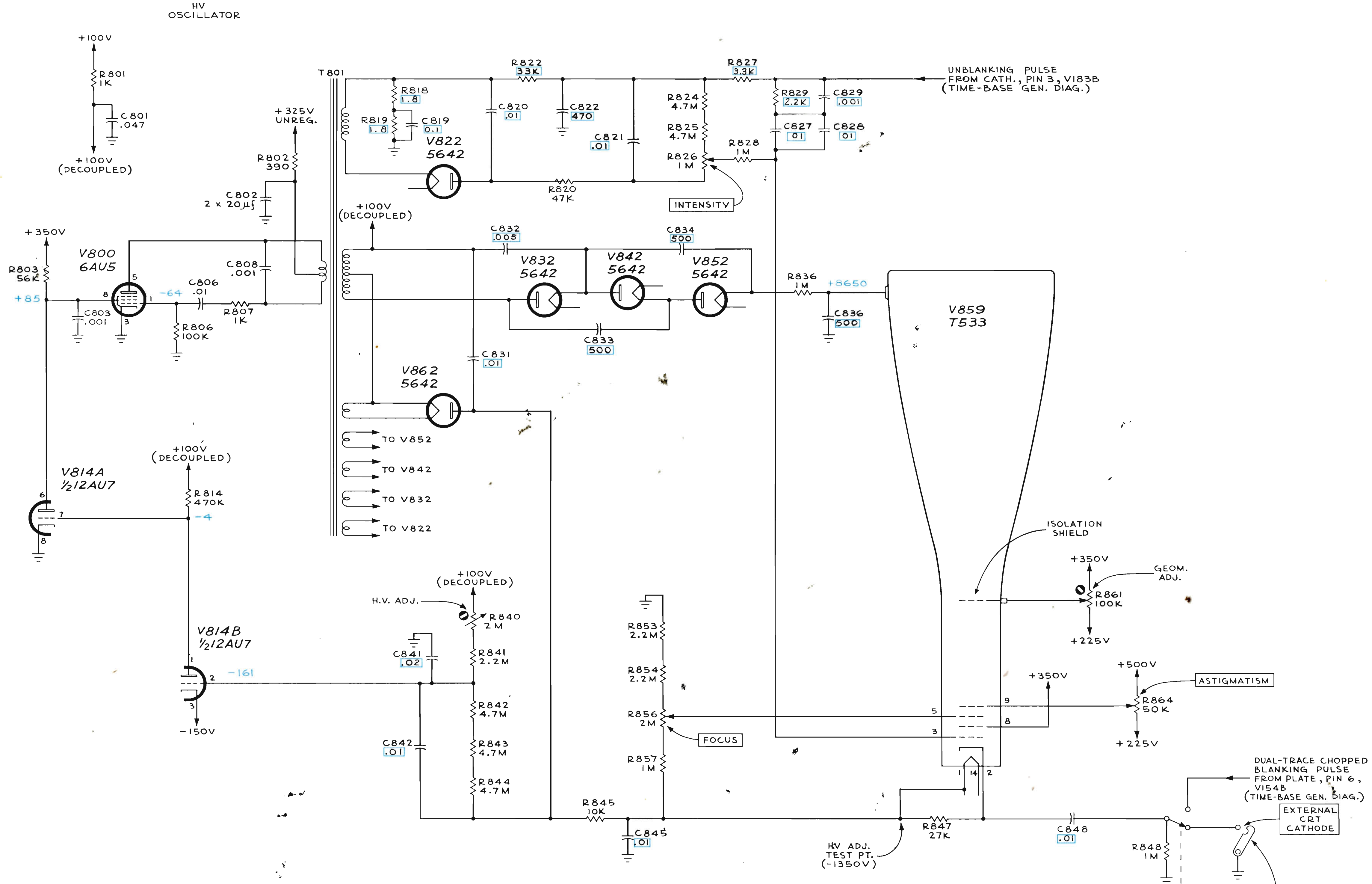
SEE ALSO **IMPORTANT** NOTE ON TIME-BASE TRIGGER DIAGRAM.

POWER SUPPLY

GAD 665

531A PWR SUP.

POWER SUPPLY



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

INTENSITY .... CCW

SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

531A A CRT

TYPE 531 A OSCILLOSCOPE

J2

CRT CIRCUIT

GAB 664

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages. If it does not, your manual is correct as printed.

EXPORT POWER TRANSFORMER

Transformer Primary

The instrument for which this manual was prepared is equipped with a special transformer. The transformer has eight primary terminals making possible six different input connections. The six primary connections are shown in Fig. 1.

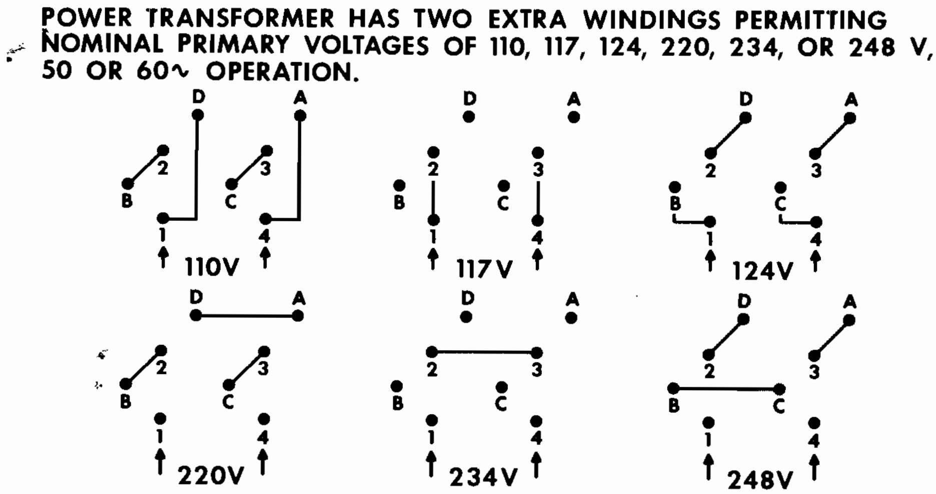


Fig.1. The power transformer has two extra windings permitting nominal primary voltages of 110, 117, 124, 220, 234, 248 volts, 50 or 60 cycle operation.

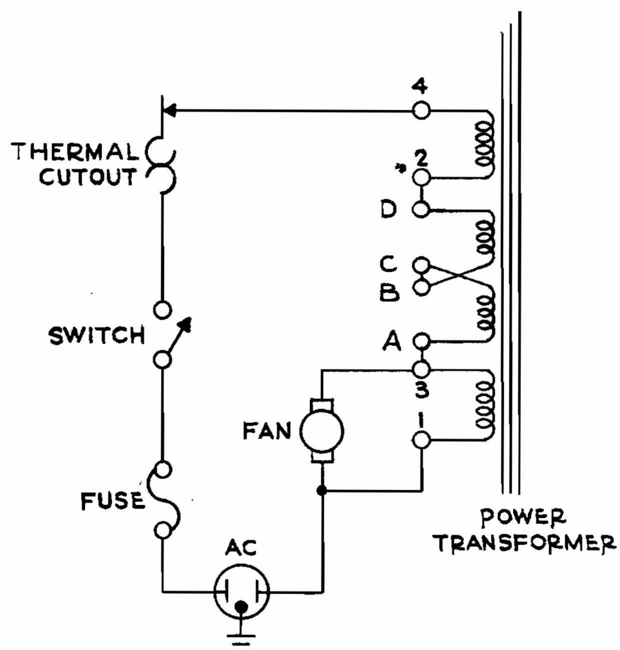


Fig. 2. When connecting the power transformer for operation with a supply voltage of 200 volts or more, be sure that the fan is connected between pins 1 and 3 of the primary. This is to insure that the fan is supplied with no more than 125 volts. Fig. 2 shows a typical high-voltage fan connection, using as an example the wiring for a 248 volt supply.

TYPE 531A/RM531A TENT SN 26800

PARTS LIST CORRECTIONS

CHANGE TO:

R19	301-0474-00	470K	½w	5%
R20	301-0683-00	68K	½w	5%

M11,418/966

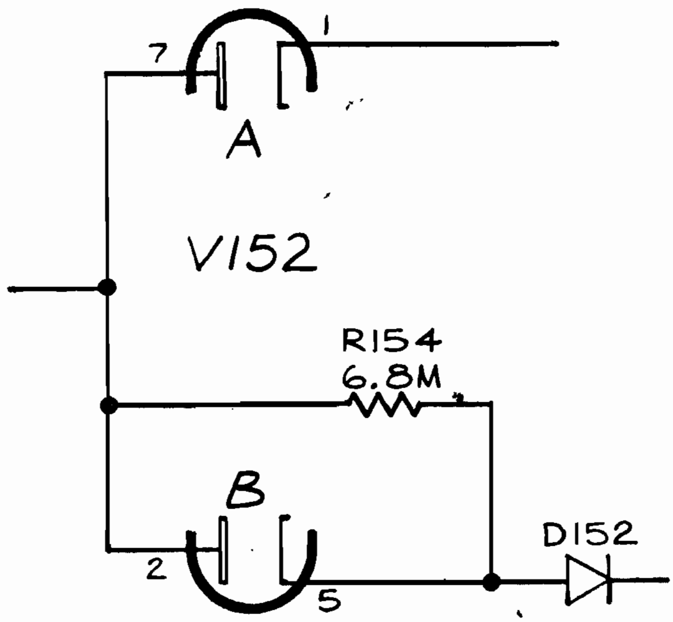
TYPE 531A/RM531A   TENT SN 26800

PARTS LIST CORRECTION

ADD:

R154	302-0685-00	6.8 MΩ	½ W	10%

SCHEMATIC CORRECTION



PARTIAL TIME-BASE GENERATOR DIAGRAM

TYPE 531A TENT SN 26750

PARTS LIST CORRECTION

CHANGE TO:

R336	310-0069-00	13 MΩ	1 W	2%

TYPE 531A/RM531A   TENT SN 26660

PARTS LIST CORRECTION

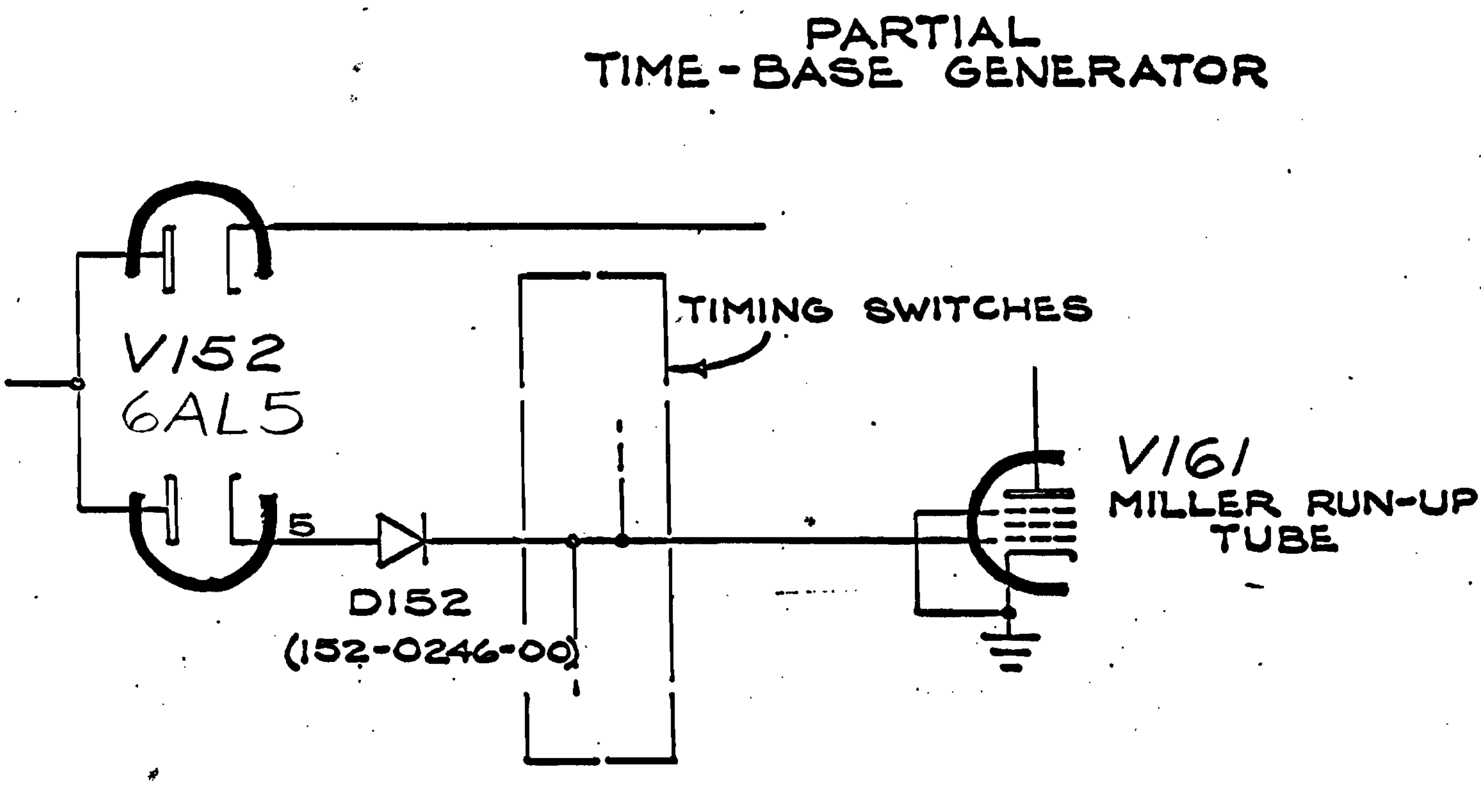
CHANGE TO:

V152	154-0016-00	6AL5

ADD:

D152	152-0246-00	Diode, Silicon

SCHEMATIC CORRECTION



M10,189/866

TYPE 531A/RM531A TENT SN 26660

PARTS LIST CORRECTION

CHANGE TO:

D642A, B, C, D	152-0066-00	Silicon
D672A, B, C, D	152-0066-00	Silicon
D679	152-0066-00	Silicon
D702A, B	152-0066-00	Silicon
D732A, B	152-0066-00	Silicon
D762A, B, C, D	152-0066-00	Silicon

TYPE 531A/RM531A   TENT SN 26890

PARTS LIST CORRECTION

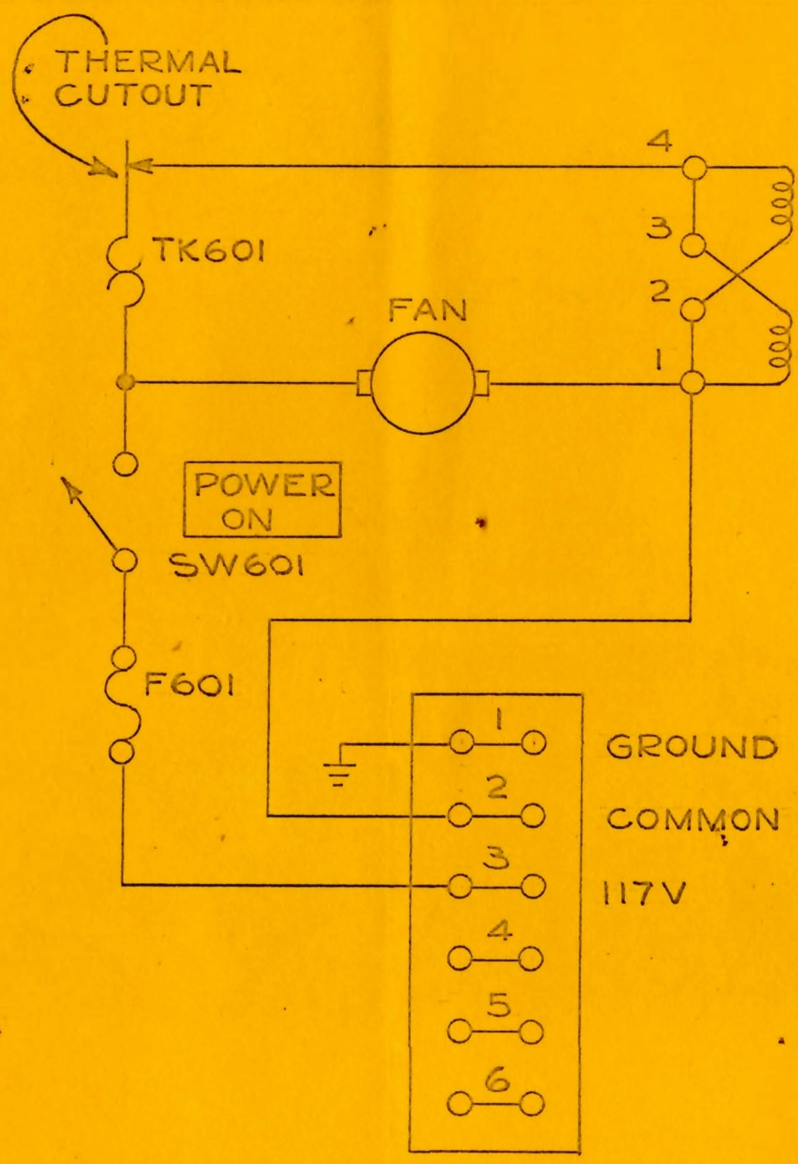
CHANGE TO:

C160F, C160G, C160H, C160J	295-0095-00	Timing Capacitor Assembly		
*Matched assembly consists of:				
C160F	285-0707-00	.001 μF	Tubular	Letter-coded
C160G	285-0607-00	.01 μF	Tubular	Letter-coded
C160H	285-0614-00	.1 μF	Tubular	Letter-coded
C160J	285-0706-00	1 μF	Tubular	Letter-coded
SW160	262-0244-01	Rotary	Wired	

*When ordering individual capacitors, letter code must be specified in addition to part number to ensure proper match of components.

The following accessories replace the standard accessory kit:

ADAPTER, Binding Post	1	013-0004-00
CLIP, Alligator	2	344-0046-00
FILTER, Light, Green	1	378-0514-00
GROUND lead, Probe, 5 inch	2	175-0124-00
HOLDER, Probe	2	352-0068-00
MANUAL, Instruction	2	070-0301-00
PINCHER Tip, Probe	2	013-0027-00
PROBE, P6006, 42" long, UHF	1	010-0125-00
PROBE, P6027, 42" long, UHF	1	010-0070-00



PART. POWER SUPPLY DIAG.

CALIBRATION

This modification will not affect the operation of the instrument. Therefore, it can be calibrated as directed in the manual.

PARTS LIST

The following parts have been added to this modified instrument. When ordering replacement parts, specify instrument type, serial number, and MOD number. Include the part number and description of the desired item.

BASE, Handle, Anodized, Black	Change	2	030-0053-01
BOLT, Spade, #4	Add	84	214-0034-00
BRACKET, Chassis Trak	Add	1 pr	030-0046-03
BRACKET, Support, Scope mtg, Left	Add	1	030-0045-03
BRACKET, Support, Scope mtg, Right	Add	1	030-0050-03
CAP, Chain, UHF, 83-1AC	Add	2	036-1009-00
CAP, Plastic, Spade Bolt	Add	84	200-0174-00
CLAMP, Cable, MS21919DG5	Add	3	036-4005-00
CLAMP, Cable, 3/16"	Add	1	343-0002-00
CLAMP, Tube, 2T, Top Hat type	Add	1	036-5000-00
CLAMP, Tube, 3T, Top Hat type	Add	2	343-0074-00
CLAMP, Tube, Small	Add	1	344-0012-00
CLAMP, Tube, Medium	Add	27	344-0013-00
CLAMP, Tube, Large	Add	11	344-0014-00
CONNECTOR, UHF, 1/2" 'D' mtg	Change	5	131-0081-00
CONNECTOR, UHF, 1/2" 'D' mtg, insul.	Change	1	131-0320-00
EXTRUSION, Poly, 4" long	Add	1	252-0564-00
FUSE, Fast-Blo, 5A 3AG	Change	1	159-0014-00
GASKET, #GS-100 (Raytheon)	Add	4	036-7013-00
GASKET, #60 Duro Rubber, 3/4 x 3/32	Add	4	036-4006-00
HANDLE, Anodized, Black	Change	2	030-0053-01
INSERT, Captive, PIN 111 (Raytheon)	Add	4	036-7012-00
PANEL, Front, Film #1719	Change	1	034-0073-00
PLATE, Frame	Change	1	030-0019-04
PLATE, Identification	Add	1	034-0072-00
PLATE, Terminal Block mtg	Add	1	030-0055-01
PLATE, Terminal Block I.D.	Add	1	030-0073-01
RETAINER, Gasket, #GSR-115 (Raytheon)	Add	4	036-7014-00
SCREEN, Filter, Iridited	Change	1	036-6025-00
SCREW, Captive, #CS-112 (Ratheon)	Add	4	036-7015-00
SPACER, Aluminum, 1/4 x 1/2	Add	2	166-0035-00
STRIP, Terminal, Kulka, 6-pin 8TB6	Add	1	036-1040-00
STUD, 8-32 x 4 1/2" long	Add	3	355-0070-00
SUBPANEL, Front	Change	1	030-0054-04
SUPPORT, Chassis Trak, 1 pr	Add	2	030-0014-02

TYPE RM31A
MOD 225D

The Oscilloscope for which this insert was prepared has been modified as follows:

Tube clamps have been added to all tubes.

The front panel TRIGGER INPUT and CAL OUT BNC connectors, and the HORIZ INPUT, +GATE OUT, VERT SIG OUT, and SAWTOOTH OUT binding posts have been changed to UHF connectors.

Chain caps have been added to the SAWTOOTH OUT and +GATE OUT connectors.

The Z-Axis input lead has been permanently connected to chassis-ground.

The standard 3-connector power cord has been replaced by a 6-connector terminal strip.

The fuse has been changed to a 5A 3AG Fast-Blo type.

The power input plug, fuse, and the CRT Cathode Selector switch have been relocated to the left rear side of the instrument.

The air filter and cover have been changed to an expanded metal fan guard and frame.

Permanent mounting brackets replace the cabinet and slide-out tracks.

A rubber gasket has been fitted to the rear edge of the special front panel.

The front panel handles and ferrules have been given a black-anodized finish.

The cabinet latches on the front panel have been replaced by screw-head assemblies.